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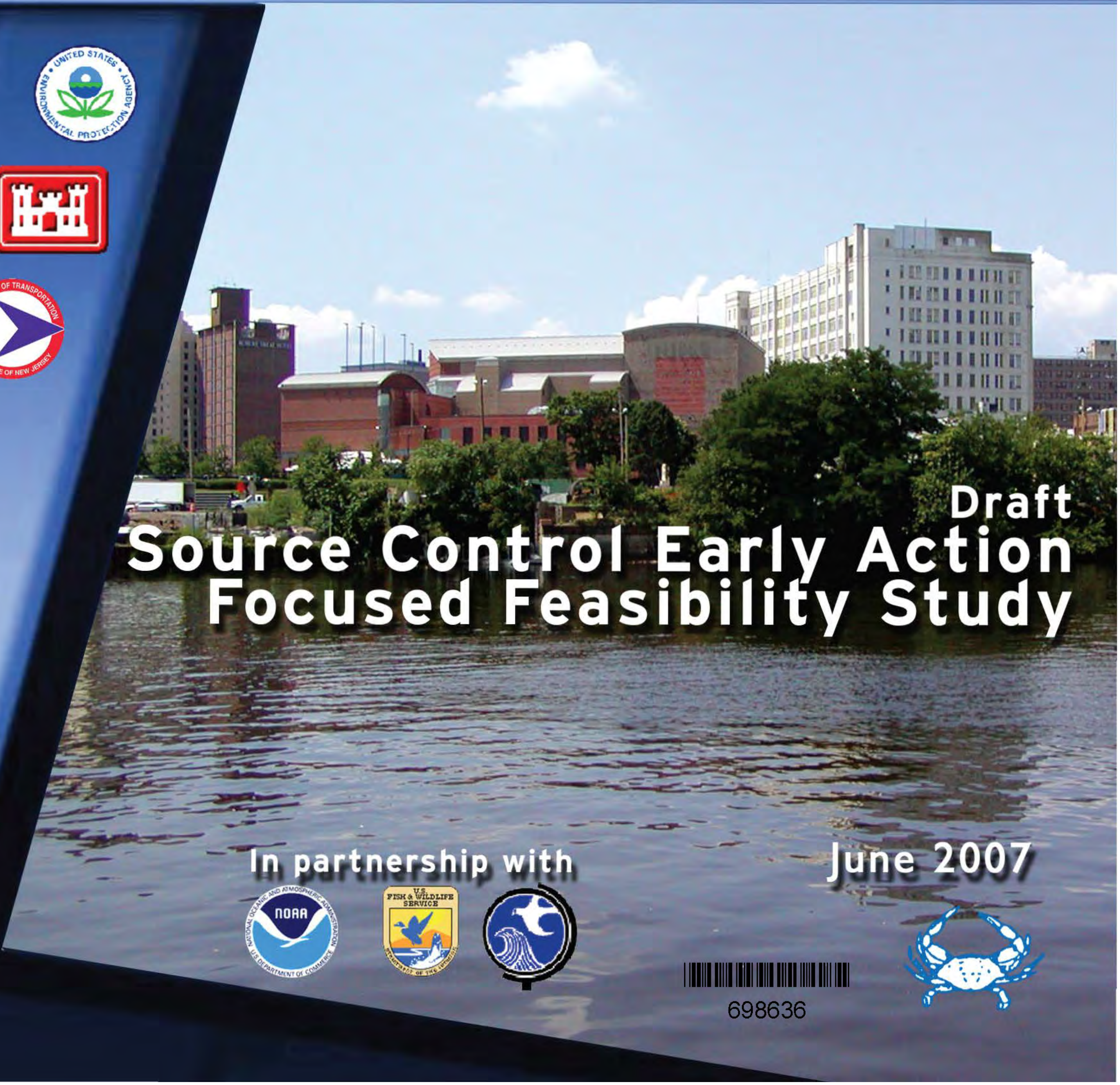
Lower Passaic River Restoration Project



Draft
Source Control Early Action Focused Feasibility Study

June 2007

In partnership with

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Draft Contractor Document: Subject to Continuing Agency Review

Lower Passaic River Restoration Project

DRAFT
SOURCE CONTROL EARLY ACTION FOCUSED FEASIBILITY STUDY

PREPARED BY:
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FOR:
US Environmental Protection Agency
US Army Corps of Engineers
New Jersey Department of Transportation

June 2007

R2-0008725

DRAFT

SOURCE CONTROL EARLY ACTION FOCUSED FEASIBILITY STUDY

LOWER PASSAIC RIVER RESTORATION PROJECT

Prepared by:
Malcolm Pirnie, Inc.

In conjunction with:
Battelle
HydroQual, Inc.

June 2007
Version 2007/06/08

EXECUTIVE SUMMARY

INTRODUCTION

The Lower Passaic River Restoration Project ("the Study") is a comprehensive study of the 17-mile tidal portion of the Passaic River and its watershed. This integrated Study is being implemented by the U.S. Environmental Protection Agency (USEPA) under the Superfund Program (the Lower Passaic River is a part of the Diamond Alkali Superfund Site); by the U.S. Army Corps of Engineers (USACE) and New Jersey Department of Transportation (NJDOT) under the Water Resources Development Act; and by the U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and New Jersey Department of Environmental Protection (NJDEP) as Natural Resource Trustees. The scope of the Study is to gather data needed to make decisions on remediating contamination in the river to reduce human health and ecological risks, improve the water quality of the river, improve and create aquatic habitat, improve human use, and reduce contaminant loading in the Lower Passaic River and the New York-New Jersey Harbor Estuary.

During the course of the Study, sediments in the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. Therefore, this Focused Feasibility Study (FFS) was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that major source. The Source Control Early Action, if undertaken, would address contaminated sediments in the lower eight miles of the Passaic River, in order to more rapidly reduce risks to human health and the environment. The Source Control Early Action, which would be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is on-going.

DESCRIPTION OF THE RIVER

The Lower Passaic River watershed was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around Great Falls in Paterson, New Jersey. In subsequent years, many industrial operations developed along the banks of the Passaic River, including manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Direct and indirect discharges from these facilities have impacted the river. Furthermore, the Lower Passaic River has received direct and indirect municipal discharges from the middle of the nineteenth century to the present time. Together, these waste streams (industrial and municipal) discharged many contaminants, including dioxins, petroleum hydrocarbons, polychlorinated biphenyls (PCB), pesticides, and metals to the Lower Passaic River.

Today, extremely contaminated surface sediments present high levels of risk to human heath and the ecosystem. A risk assessment conducted for the FFS concluded that among adults consuming 40 meals per year of fish from the Lower Passaic River over 30 years, their risk of developing cancer would be one in one hundred. This risk is greater than USEPA's risk range established in the Superfund Program of one in ten thousand to one in a million. Approximately 65 percent of the human health cancer risk is associated with the presence of dioxin. Most of the remaining cancer risk (approximately 33 percent) is from PCB, while all other contaminants combined contribute approximately two percent. Accordingly, fish consumption advisories have been in place for many years due to contamination from dioxins and PCB. Similar risks are present for wildlife, although metals and pesticides cause most of the risk to fish, while dioxin and PCB cause most of the risks for animals and birds that eat fish.

An important component of the region's historical development and urbanization was the deepening of the river to permit commercial navigation into the city of Newark and farther upriver. Several large dredging projects at the beginning of the twentieth century established and maintained a navigation channel through more than 15 miles of the river.

Since the 1940s, there has been little maintenance dredging and none since the early 1980s. Consequently, the river has accumulated substantial sediment deposits particularly in the lower eight miles, measuring up to 25 feet thick. Less sedimentation has occurred upstream because of the faster flowing narrower channel. Tidal mixing has distributed contamination throughout the lower eight miles, as well as upriver and into Newark Bay and the New York – New Jersey Harbor Estuary.

Sediment contamination is even greater in deeper sediments than at the surface. Sediment erosion due to the back-and-forth motion of the tides and storm events is most likely responsible for continuing releases of contaminants from the river bed. As a fraction of all of the solids sources to the Lower Passaic, resuspension of deeper sediments comprises about 10 percent of the total annual deposition. However, resuspension accounts for over 95 percent of the dioxin accumulating in the river bottom, and at least 40 percent of PCBs, pesticides and mercury accumulating in the river.

The Lower Passaic River is also a major source of contaminants to Newark Bay. Sediment transport from the Lower Passaic River to Newark Bay delivers the contaminants found in Newark Bay's surficial sediments, particularly dioxin. It is estimated that the Lower Passaic River contributes approximately 10 percent of the average annual amount of sediment accumulating in Newark Bay, and more than 80 percent of the dioxin accumulating in the Bay. A recent study of dioxin contamination in New York Harbor (Chaky, 2003) suggests that the Lower Passaic River dioxin signature can be traced through the entire Harbor. The Lower Passaic River also contributes approximately 20 percent of the mercury to Newark Bay.

Sediment contamination is not the only problem in the Lower Passaic River. The communities that line the banks of the Lower Passaic River are prone to flooding. Development of the banks and the watershed has eliminated vital wetlands and floodplains, so that flood events pose economic and public safety risks. Finally, the State of New Jersey has reaffirmed its need for the river's navigation infrastructure, as its communities develop plans for use of a restored river in the future. The State's needs are documented in this report and help define the reasonably anticipated future use for the Lower Passaic River.

REMEDIAL ACTION OBJECTIVES AND TARGET AREAS

Remedial Action Objectives (RAOs) were established to describe what the cleanup is expected to accomplish, and preliminary remediation goals (PRGs) were developed as targets for the cleanup to meet in order to protect human health and the environment.

The RAOs are as follows:

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of contaminants of potential concern (COPCs) in fish and shellfish.
- Reduce the risks to ecological receptors by reducing the concentration of contaminants of potential ecological concern (COPECs) in fish and shellfish.
- Reduce the mass of COPCs and COPECs in sediments that are or may become bioavailable.
- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

Background contaminant contributions to sites should be considered to adequately understand contaminant sources and establish realistic risk reduction goals. Investigation of sediment contaminant concentrations in the Upper Passaic River above the Dundee Dam has revealed the presence of historic and ongoing upstream sources of inorganics, pesticides, and PCB that are significant in comparison to contaminant concentrations in the Lower Passaic River. USEPA guidance defines "*background*" as constituents and locations that are not influenced by releases from the site and includes both anthropogenic and naturally derived constituents. The dam physically isolates the proximal Dundee Lake and other Upper Passaic River sediments from Lower Passaic

River influences while the Lower Passaic River receives contaminant loads from above the dam. The proximity of these sediments to the proposed remediation area and demonstrated geochemical connection to a portion of the Lower Passaic River sediment contamination strongly argues in favor of their consideration as representative of "background" for the Lower Passaic River.

A number of human health and ecological risk-based concentrations were considered in the development of PRGs. The developed risk-based threshold concentrations were calculated from cancer risks and toxicity for human receptors who potentially consume between one and 40 meals of fish or shellfish a year from the river and from toxicity to benthic organism and wildlife. The background concentrations derived from recent sediment data from above Dundee Dam were found to be above the risk-based thresholds. Since the Superfund program, generally, does not clean up to concentrations below natural or anthropogenic background levels (USEPA, 2002b), background concentrations were selected as PRGs. Table A lists the background concentrations of COPECs and COPCs, selected as the PRGs.

Table A: Selected PRGs

Contaminant	Background Concentration (ng/g)
Copper	80,000
Lead	140,000
Mercury[a]	720
Low Molecular Weight PAHs	8,900
High Molecular Weight PAHs	65,000
Total PCB	660
Total DDx	91
Dieldrin	4.3
Chlordane	92
2,3,7,8-TCDD	0.002

(a) All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

The COPC and COPEC concentrations known to exist in the surface sediments of the lower 8 miles are much greater than these PRGs. For this reason a remedial strategy that can reduce the concentrations to at least the level of background is necessary to begin to achieve the RAOs.

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action will need to be implemented above Dundee Dam to identify and reduce or eliminate those background sources. Such a separate action might include identifying facilities above the dam with on-going contributions to the Upper Passaic River, or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or State of New Jersey regulatory programs.

To identify distinct areas that, if remediated, may result in the achievement of RAOs, a series of geospatial and geochemical analyses were conducted. During these analyses, three target areas were identified for consideration: the Primary Erosional Zone (68 acres), the Primary Inventory Zone (63 acres), and the Area of Focus (650 acres, lower eight miles). The Primary Erosional Zone is an area of the Lower Passaic River in which there exists a greater amount of surface area that may erode as compared to other areas of the river. The Primary Inventory Zone is an area of the Lower Passaic River in which there exists a relatively greater contaminant inventory (mass) as compared to other areas of the river. The Area of Focus encompasses the entire (bank-to-bank) river area from RM0 to RM8.3, which contains elevated COPC and COPEC concentrations in surface sediment and contaminant inventory that is at risk of being eroded and transported over time due to high flow events as well as typical flow and tidal conditions.

Future concentrations of COPECs and COPCs in the Lower Passaic River surface sediments were estimated using an empirical method. The sediment concentration forecasting supported risk evaluations, which considered the following scenarios: No Action (including natural recovery), remediating the Primary Erosion Zone, remediating the Primary Inventory Zone, and remediating the Area of Focus.

These evaluations of risk, development of PRGs, and estimation of future concentrations were used to evaluate the benefit of remediating each of the three target areas. Based on the estimated risk reduction, No Action or the remediation of only the Primary Erosional Zone and/or the Primary Inventory Zone will not achieve residual risks within the USEPA risk range of one in ten thousand to one in a million within reasonable time frames. In addition, sediment concentrations exceeding PRGs have been identified throughout the Area of Focus and remediating only the Primary Erosion Zone and/or the Primary Inventory Zone does not address these continuing contaminant sources. However, remediating the Area of Focus reduces the COPC and COPEC concentrations in the surface sediments over the long term to the background concentrations that are introduced to the Lower Passaic River from the Upper Passaic River. Active remediation of the Area of Focus is also predicted to reduce the human health risk by 95 to 98 percent (fish versus crab consumption) and the ecological hazard by 78 to 98 percent (species dependent), which meets the RAOs. It is important to note that regardless of the PRG or risk levels that need to be achieved, remediating the Area of Focus achieves clean-up of 2,3,7,8-TCDD, which is responsible for about 65 percent of the human health cancer risk, 40 years faster than it would be achieved by No Action. The reduction of other COPCs and COPECs is also accelerated by the remediation of the Area of Focus. For these reasons, all active alternatives were developed to remediate the Area of Focus, which encompasses the fine-grained sediments of the lower eight miles in their entirety.

DEVELOPMENT OF ALTERNATIVES

Available technologies were analyzed in order to develop alternatives for remediating the sediments of the lower eight miles. Consistent with the intent of an early action, preference was given to technologies that have been proven in other full-scale remedies and could be designed and implemented in the near term, without additional lengthy research. For the in-river aspects of the remediation, remedial technology classes selected for analysis were dredging (mechanical) and engineered capping (sand and armor). For management of dredged materials, nearshore confined disposal facilities (CDF) were selected for analysis, either as the only management solution or in combination with a local thermal treatment facility.

In addition to the No Action alternative that the Superfund program requires to be evaluated, six active alternatives were developed and evaluated:

- Alternative 1: Removal of Fine Grained Sediment from Area of Focus.
- Alternative 2: Engineered Capping of Area of Focus.
- Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel.
- Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage.
- Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage.
- Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone.

Following the completion of active remediation in the river, each of these alternatives relies on monitored natural recovery, with institutional controls, to achieve protectiveness.. In addition, separate source control actions above Dundee Dam, when implemented, will shorten the time frame within which the active alternatives achieve protectiveness.

DETAILED ANALYSIS OF ALTERNATIVES

The Superfund program has established nine criteria for evaluating remedial alternatives. The first two criteria are threshold criteria that must be met by each alternative: overall protection of human health and the environment, and compliance with applicable or relevant and appropriate requirements (ARARs). The next five criteria are primary balancing criteria upon which the analysis is based: long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; short-term effectiveness; implementability; and cost. The No Action alternative and six active alternatives were evaluated using these seven criteria, with the last two, the modifying criteria of state acceptance and community acceptance, left to be evaluated following the Proposed Plan.

A summary of the comparison of the No Action alternative and the six active remediation alternatives to the Superfund criteria is included in Table B. A summary of important quantitative estimates for No Action alternative and the six active alternatives is included in Table C. A graphical presentation of the costs for the six active alternatives is shown on Figure A.

All active remediation alternatives rely on natural recovery processes in the river, as well as continued introduction of relatively cleaner sediments from above the Dundee Dam, for continued improvement following active remediation of sediments in the lower eight miles to control that source of contaminants. In contrast to the other alternatives, the No Action alternative does not require any active measures to address the contaminated sediment; thus is it technically feasible and would result in comparatively little cost. However, the No Action alternative would take much longer to achieve remedial action objectives compared to the active alternatives, and would be ineffective at reducing toxicity, mobility and volume of contaminated sediments. While active alternatives would result in rapidly cutting off the source of much contamination to Newark Bay and its gradual improvement, No Action would allow the continued long-term mobilization of contaminated sediments to Newark Bay and other areas in the New York – New Jersey Harbor Estuary. The No Action alternative would not support the reasonably anticipated future uses of the river for navigation. Finally, the No Action alternative would not meet RAOs within a reasonable time frame and would thus not be protective of human health and the environment.

In addition to cost, the major differences among the six active alternatives are related to the volume of material to be dredged, the final elevation of the remediated surface in various stretches of the lower eight miles (related to compatibility with future use objectives), and the extent of engineered capping employed versus backfilling. As shown on Table B, all active alternatives are considered equivalent for the criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs. The active alternatives can be distinguished from each other for the other five criteria as follows:

- Long Term Effectiveness and Permanence: Alternatives 1 and 3 rely most heavily on backfill (which would not be maintained) following dredging to historically dredged surfaces, and Alternatives 2 and 4 rely most on engineered capping, which would be maintained in perpetuity. Dredging followed by backfilling and capping are judged to have similar adequacy in addressing the contamination in the fine-grained sediments, and the reliability of both depends on proper design and implementation. However, the long-term reliability of capping depends heavily on the consistency and sufficiency of future cap maintenance activities, while the long-term reliability of backfill placed would not be monitored.
- Reduction of Toxicity, Mobility, and Volume: the active alternatives have varying dredging removal volumes that range from 1.2 million cubic yards to 11 million cubic yards.
- Short Term Effectiveness: larger removal volumes would have a greater potential for short term impacts from dredging resuspension and associated construction activities (see estimated construction durations on Table C).
- Implementability: the active alternatives are distinguished primarily on the basis of flooding (considerable flooding increases would occur for Alternatives 2 and 4); also, certain alternatives would require administrative changes to the navigation channel authorization (Alternatives 2, 4, 5, and 6).
- Cost: the active alternatives range in cost from $0.9 billion to $2.3 billion.

Table B: Summary of Detailed Analysis of Alternatives

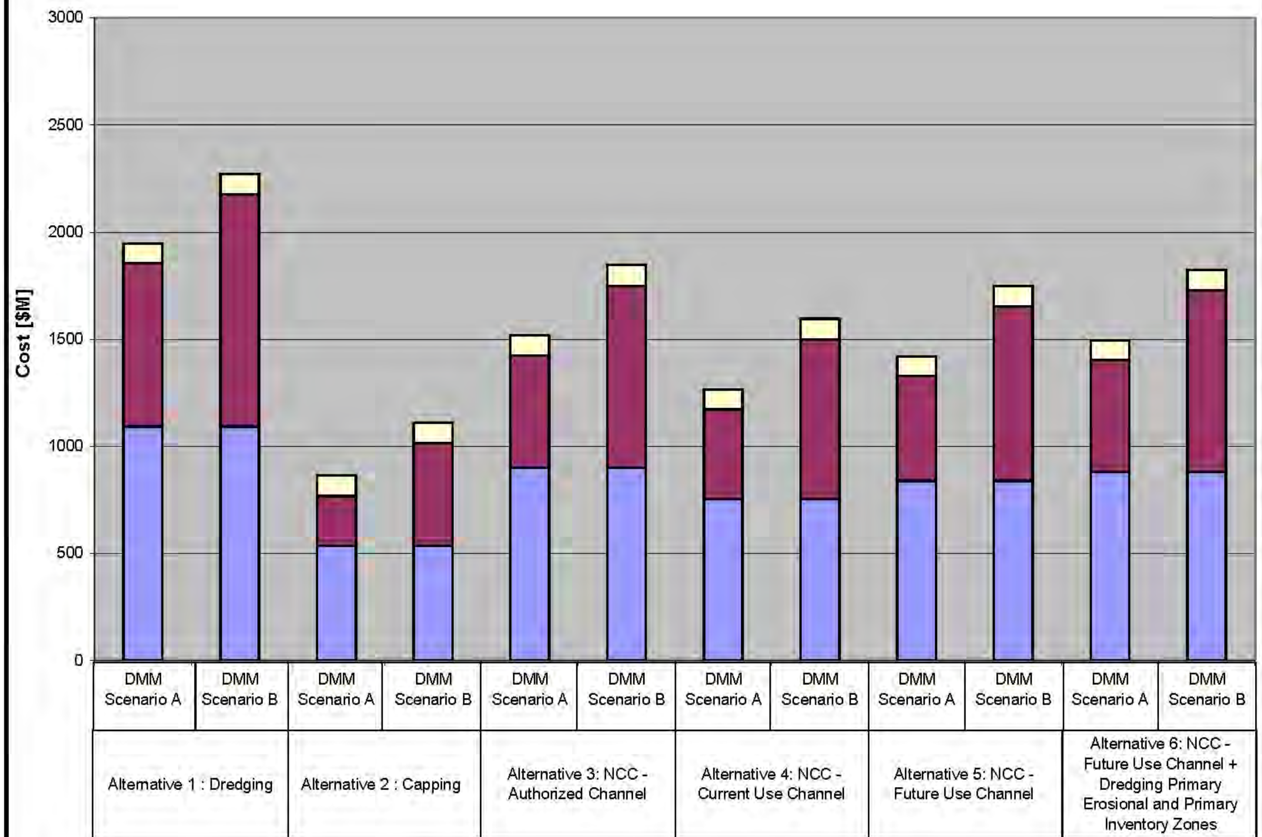
Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short Term Effectiveness	Implementability	Cost	
							DMM Scenario A[4]	DMM Scenario B[5]
No Action	**Not protective.** Natural recovery processes would achieve some reduction in risk from current levels, but human health and ecological risks continue to be above acceptable levels. In addition, the contaminated sediment load from the Lower Passaic River to Newark Bay and the New York-New Jersey Harbor Estuary would continue.	None of the identified action-specific or location-specific ARARs are applicable to the No Action alternative.	Cancer risks reduced to 4×10^{-3} for ingestion of fish and 3×10^{-3} for ingestion of crab. For fish ingestion, HI for adult reduced to 6.8 and child to 31. For crab ingestion, HI for adult reduced to 5.2 and child to 27. Mink HI reduced to 52. Heron HI reduced to 5.	None	Some decreases in existing risks are achieved from natural recovery processes, but acceptable levels of risk are not achieved within a reasonable time frame (30 years).	Implementable. Requires no action. Gradual increase in flooding impact. Change in authorized depth required.	Not applicable	Not applicable
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	**Protective.** Human health risks are reduced to the risk range. Substantial ecological improvements occur in a substantially shorter period of time. Institutional controls will be necessary to protect human health after remedy is implemented, during period of monitored natural recovery. Control of sources above Dundee Dam will accelerate time to reach risk range.	Alternative 1 through 6 will be designed and carried out in accordance with applicable ARARs and accepted best management practices.	Cancer risks reduced to 5×10^{-4} for ingestion of fish and 4×10^{-4} for ingestion of crab. For fish ingestion, HI for adult reduced to 4.7 and child to 22. For crab ingestion, HI for adult reduced to 3.5 and child to 19. Mink HI reduced to 6. Heron HI reduced to 2. Alternative 1 relies exclusively on placement of a backfill layer to provide a measure of control in the event that residual contamination poses health risks. This alternative does not include an engineered cap, because the intent is for the contaminated fine-grained sediment to be removed with the assumption that the underlying less-contaminated sand material will not erode to any significant extent. The backfill layer is not intended to be maintained, in contrast to the engineered cap in Alternative 2 whose thickness must be maintained in the long term in order to ensure protectiveness of contaminant inventory left underneath. Alternatives 3, 4, 5, and 6 rely on varying combinations of backfill and engineered cap, depending on the amount of contaminated inventory left after dredging. Of these four alternatives, Alternative 3 proposes removing the most fine-grained sediment down to the underlying sandy layer, while Alternative 4 proposes leaving behind the most contaminant inventory, so that Alternative 3 relies most heavily on backfill and Alternative 4 relies most on engineered capping. The reliability of both dredging and engineered caps depends upon proper design and implementation, while the reliability of capping also depends on the consistency and sufficiency of future maintenance.	Removal of 11 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.7 million cy would irreversibly destroy contaminants.	Greatest amount of removal results in greatest potential for disturbance and environmental impact.	Implementable. Slight decrease in flooding. No change in authorized depth required.	\$2.0 Billion	\$2.3 Billion
Alternative 2: Engineered Capping of Area of Focus				Removal of 1.2 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.2 million cy would irreversibly destroy contaminants.	Lowest amount of removal results in lowest potential for disturbance and environmental impact.	Considerable increase in flooding. Change in authorized depth required.	\$0.9 Billion	\$1.1 Billion
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel				Removal of 7.1 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.7 million cy would irreversibly destroy contaminants.	Relatively moderate amount of removal results in moderate potential for disturbance and environmental impact.	Implementable. Slight decrease in flooding. No change in authorized depth required.	\$1.5 Billion	\$1.9 Billion
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage				Removal of 3.2 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.7 million cy would irreversibly destroy contaminants.	Relatively lower amount of removal results in relatively lower potential for disturbance and environmental impact.	Considerable increase in flooding. Change in authorized depth required.	\$1.3 Billion	\$1.6 Billion
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use				Removal of 6.3 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.7 million cy would irreversibly destroy contaminants.	Relatively moderate amount of removal results in moderate potential for disturbance and environmental impact.	Implementable. Slight decrease in flooding. Change in authorized depth required.	\$1.4 Billion	\$1.8 Billion
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone				Removal of 7.2 million cy of contaminated sediment would permanently reduce volume of contaminants in Area of Focus. Thermal treatment of 1.7 million cy would irreversibly destroy contaminants.	Relatively moderate amount of removal results in moderate potential for disturbance and environmental impact.	Implementable. Slight decrease in flooding. Change in authorized depth required.	\$1.5 Billion	\$1.8 Billion

Table C: Summary of Quantitative Estimates for Six Remedial Alternatives

<table>
<tr><th rowspan="2">Alternatives</th><th rowspan="2">Navigation Usage
• Navigation channel depths[1]</th><th rowspan="2">Flooding[2] (additional flooding)</th><th rowspan="2">Dredging Volume (millions of cubic yards)</th><th rowspan="2">Construction Duration (years)</th><th>Human Health Risk Assessment[3]</th><th>Ecological Risk Assessment[3]</th><th colspan="2">Total Present Worth Cost</th></tr>
<tr><th>Fish Consumption[4]</th><th>Heron[5]</th><th>DMM Scenario A[6]</th><th>DMM Scenario B[7]</th></tr>
<tr><td>No Action</td><td>Similar to Current Use Alternative 4; limits feasibility of future channel maintenance.</td><td>Gradual increase with time (not estimated)</td><td>0</td><td>Not applicable</td><td>4 E-03</td><td>5</td><td>Not applicable</td><td>Not applicable</td></tr>
<tr><td>Alternative 1: Removal of Fine-Grained Sediment from Area of Focus</td><td>Authorized channel dimensions accommodated (see Alternative 3 below).</td><td>Decrease (not estimated)</td><td>11.0</td><td>12</td><td rowspan="6">5 E-04 (95% reduction compared to current)</td><td rowspan="6">2</td><td>$2.0 Billion</td><td>$2.3 Billion</td></tr>
<tr><td>Alternative 2: Engineered Capping of Area of Focus</td><td>Navigation significantly reduced.</td><td>Considerable Increase (93 acres)</td><td>1.1</td><td>6</td><td>$0.9 Billion</td><td>$1.1 Billion</td></tr>
<tr><td>Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel</td><td>Authorized channel dimensions accommodated.
• 30' from RM0 to RM2.5
• 20' from RM2.5 to RM4.6
• 16' from RM4.6 to RM8.1
• 10' above RM8.1</td><td>Decrease (not estimated)</td><td>7.0</td><td>8</td><td>$1.5 Billion</td><td>$1.9 Billion</td></tr>
<tr><td>Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage</td><td>Current navigation usage accommodated.
• 30' from RM0 to RM1.2
• 16' from RM1.2 to RM2.5
• Navigation above RM2.5 significantly reduced</td><td>Considerable Increase (24 acres)</td><td>4.4</td><td>6</td><td>$1.3 Billion</td><td>$1.6 Billion</td></tr>
<tr><td>Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use</td><td rowspan="2">Anticipated future navigation usage accommodated.
• 30' from RM0 to RM1.2
• 16' from RM1.2 to RM3.6
• 10' above RM3.6</td><td>Decrease (-17 acres)</td><td>6.1</td><td>7</td><td>$1.4 Billion</td><td>$1.8 Billion</td></tr>
<tr><td>Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone</td><td>Decrease (not estimated)</td><td>7.0</td><td>8</td><td>$1.5 Billion</td><td>$1.8 Billion</td></tr>
</table>

Notes:

(1) Navigation channel depths are provided in feet below mean low water.
(2) Flood estimates are provided for the 100-year return interval river flow event.
(3) Risk reductions presented are for 30 year timeframe. Alternatives 1 through 6 rely on monitored natural recovery with institutional controls in place to achieve 1E-04 and HI=1 in subsequent years. In addition, separate source control actions above Dundee Dam, when implemented, will accelerate the time frame to reach 1E04 and HI=1.
(4) A human health risk assessment was also conducted for the scenario of crab consumption. More information is presented in Appendix C: Risk Assessment.
(5) An ecological risk assessment was also conducted for other species. More information is presented in Appendix C: Risk Assessment.
(6) Dredged Material Management Scenario A: Nearshore Confined Disposal
(7) Dredged Material Management B: Nearshore Confined Disposal, Storage, Thermal Treatment, and Beneficial Use



Legend

Operation and Maintenance Costs

Dredged Material Management Costs

Capital Costs

Notes

DMM Scenario A: Nearshore Confined Disposal

DMM Scenario B: Nearshore Confined Disposal, Storage, Thermal Treatment, and Beneficial Use

Acronyms

DMM = Dredged Material Management

NCC = Navigationally Constrained Capping

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Remedial Alternatives Cost Comparison

Lower Passaic River Restoration Project

Figure A

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MALCOLM PIRNIE

R2-0008739

LOWER PASSAIC RIVER RESTORATION PROJECT
SOURCE CONTROL EARLY ACTION FOCUSED FEASIBILITY STUDY

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LIST OF FIGURES

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LIST OF APPENDICES

Mention of trade names or commercial products in this Focused Feasibility Study is for purposes of evaluating remedial alternatives only, and does not constitute endorsement of any product or manufacturer by the United States Environmental Protection Agency.

1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION

1.1.1 Purpose

The Lower Passaic River Restoration Project (herein referred to as the Study) is a comprehensive study of the 17-mile tidal portion of the Passaic River and its watershed (Figure 1-1). During the course of the Study, the sediments of the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area. Therefore, a Focused Feasibility Study (FFS) was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that source. This Source Control Early Action, if undertaken, would address some or all of the contaminated sediments in the lower eight miles of the Passaic River, in order to reduce risks to human health and the environment. The Source Control Early Action, which would be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile study is on-going.

The Area of Focus for this FFS is the predominantly fine-grained, contaminated sediment present in the Brackish and Transitional Sections[1] of the Lower Passaic River. Geomorphological data suggest fine-grained sediments exist in a contiguous stretch up to approximately river mile (RM) 8. Therefore, remedial alternatives have been developed to consider remedial action in the lower 8 miles. While the preponderance of available contaminant data represents the area between RM1 and RM7, the Conceptual Site Model (CSM) (Appendix A) suggests that RM0 to RM1 and RM7 to RM8 will behave similarly to the area between RM1 to RM7.

[1] As described in the Conceptual Site Model (Appendix A), the Lower Passaic River may be divided into three sections: a Freshwater section dominated by freshwater flow entering over Dundee Dam, a Brackish section dominated by saline waters from Newark Bay, and a Transitional section where the two mix.

Historical data and data gathered during remedial investigation (RI) activities to date were used to develop the CSM, identify potential target areas for remediation, and characterize current risk. Potentially applicable technologies have been identified, evaluated for their suitability for use at the site, and assembled into remedial alternatives. A comparative analysis of these remedial alternatives, consistent with the United States Environmental Protection Agency (USEPA) guidance documents for preparing feasibility studies (USEPA, 1988) and for addressing contaminated sediment (USEPA, 2005), is also presented.

1.1.2 Organization of the Focused Feasibility Study

The FFS is organized into the following sections:

Section 1.0, INTRODUCTION: This section provides introductory and background material, as well as a CSM that summarizes the nature and extent of contamination in the Study Area, as well as the fate and transport of suspended solids and contaminants in the Lower Passaic River and Newark Bay.[2] This section also includes definitions for terms used in this document.

Section 2.0, DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND SELECTION OF TARGET AREAS: This section presents the potential applicable or relevant and appropriate requirements (ARARs), which are the Federal and State environmental regulations that may pertain to a remedial action, as well as other to-be-considered (TBC) criteria, which are non-promulgated guidance, advisories, and proposed standards issued by Federal or State agencies. This section also presents the current knowledge of contaminant bioaccumulation and risks to human health and the environment posed by contaminants in the Area of Focus, as well as a prediction of future surface concentrations generated using the Empirical Mass Balance Model (Appendix D), which also refines conclusions presented in the CSM. The criteria for identifying areas

[2] The CSM is presented in full in Appendix A and illustrates biotic, as well as physical and chemical, processes; human health and ecological risk pathways and receptors are presented in the Risk Assessment (Appendix C).

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of the river for potential remediation are presented, along with Remedial Action Objectives (RAOs) and Preliminary Remediation Goals (PRGs).

Section 3.0, IDENTIFICATION AND SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGY CLASSES, AND PROCESS OPTIONS: This section presents a review of general response actions, remedial technology classes, and process options that may be used to achieve the RAOs identified in Section 2.0 "Development of Remedial Action Objectives and Selection of Target Areas." The process options are screened for applicability in developing remedial alternatives for the Area of Focus.

Section 4.0, DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES: This section presents the development and conceptual description of remedial alternatives. In addition to the No Action alternative, six active remedial alternatives are presented for remediating the lower 8 miles of the Passaic River.

Section 5.0, DETAILED ANALYSIS OF ALTERNATIVES: This section presents a detailed description and analysis of features unique to each alternative, according to each of the seven Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation criteria required to be addressed in the FFS report. Also included is a comparative analysis of the remedial alternatives.

Section 6.0, ACRONYMS: This section provides the definitions for the acronyms used in this document.

Section 7.0, REFERENCES: This section provides a list of the references used in this document.

1.2 DEFINITION

In order to aid the reader, the following definitions of terms frequently used in this document are provided.

- Area of Focus: Contaminated sediments present in RM0 to RM8.3 [remedial investigation and feasibility study (RI/FS) RM0 to RI/FS RM8]. (RM systems are also defined in this section.)
- Armor: Material (*e.g.*, stone) placed over a cap to withstand erosive forces.
- Authorized Channel: The navigation channel with limits as determined by the United States Congress and entrusted to the United States Army Corps of Engineers (USACE).
- Backfill: Material placed to mitigate dredging residuals; unlike a cap, backfill is not required to be maintained after placement.
- Cap or Engineered Cap: Layer of material placed over contaminated sediment to reduce migration of contamination from the underlying sediment.
- Confined Disposal Facility (CDF): Basin designed to accept dredged material, typically using berms, dikes, or walls to isolate dredged material from surroundings and provide gravity dewatering; can be used in upland, nearshore, or off-shore (island) configurations.
- Contained Aquatic Disposal (CAD): Placement of dredged material into an excavated or existing subaqueous depression, followed by placement of cover material.
- Contaminant Inventory: The quantity of a particular contaminant in a given area or river reach with units of mass.
- Far Field: Area in an aquatic system in which a sediment plume due to a disturbance (*e.g.*, dredging) will be relatively well-mixed in the water column and the particles will remain suspended indefinitely; empirically defined in this system as greater than approximately 1000 feet (300 meters) from the point of disturbance.
- Fine-Grained Sediment: Sediment that falls predominantly in the silt or clay category as defined under the Unified Soil Classification System.
- Head-of-Tide: Up-estuary limit of the influence of tidal forcing on water surface elevation.
- Hot Spot: Area of sediment contamination that can be distinguished from adjacent sediments by a relatively sharply defined gradient in chemical concentration or mass per unit area.

- Hot Zone: Extensive area of sediment contamination characterized by a large inventory with chemical concentration or mass per unit area that declines only gradually with distance from its centroid and has no well-defined boundary.
- Mudflat: Area of fine-grained, consolidated sediment (at least 50 feet wide for practical purposes) that is intermittently exposed and submerged by tidal fluctuation.
- Navigational Channel (often shortened to "Channel"): Portion of a waterbody which is defined to accommodate the passage of waterborne vessels.
- Near Field: Area in an aquatic system within which a sediment plume due to a disturbance (*e.g.*, dredging) will not be reliably well-mixed in the water column and many suspended particles will settle out; empirically defined in this system as less than approximately 1000 feet (300 meters) from the point of disturbance.
- Primary Erosional Zone: Area of the Lower Passaic River in which there exists a greater amount of surface area that may erode as compared to other areas of the river.
- Primary Inventory Zone: Area of the Lower Passaic River in which there exists a relatively greater contaminant inventory as compared to other areas of the river.
- River Mile System: Two systems exist for identifying locations by RM in the Lower Passaic River. The system used in this document to identify locations in the river is based on measurements made, using units of RM, along the centerline of the USACE navigation channel, starting from the downriver terminus of the navigation channel. However, Appendix A "Conceptual Site Model," Appendix C "Risk Assessment," Appendix D "Empirical Mass Balance Model," and other locations (*e.g.*, figures) where specifically noted, use a slightly (about 1/4 mile) different river mile system, which is referred to in this document as the "RI/FS RM" system. The RI/FS RM system uses measurements made in units of RM along a centerline that is equidistant from each shore. Figure 1-2 displays both river mile systems. In instances in this document when precision is required, the location will be provided using both systems, first using the USACE navigation channel river mile designation as a reference, and parenthetically using the RI/FS river mile designation as a reference. In instances when approximate location is sufficient, the location will be provided only using the USACE system, except in the appendices mentioned above, where the RI/FS system will be used.

- Shoal: Area between the navigation channel and the shoreline.
- Thalweg: Deepest portion of river cross-section, in which greatest water velocities occur.

1.3 BACKGROUND INFORMATION

1.3.1 Study Background

The Study is an interagency effort to remediate and restore the complex ecosystem of the Lower Passaic River, which is the 17-mile tidally-influenced portion of the river located in northern New Jersey. The Study Area (118 square miles) is defined as the Lower Passaic River and its basin, which comprises the tidally-influenced portion of the river from the Dundee Dam (RM17) to Newark Bay (RM0), and the watershed of this river portion downstream of the dam, including the Saddle River, Second River, and Third River (Figure 1-1). The Lower Passaic River is an Operable Unit of the Diamond Alkali Superfund Site in Newark, New Jersey.

The USEPA, USACE, and New Jersey Department of Transportation (NJDOT) have partnered with the National Oceanic and Atmospheric Administration (NOAA), United States Fish and Wildlife Service (USFWS), and New Jersey Department of Environmental Protection (NJDEP) to bring together the authorities of the CERCLA and the Water Resources Development Act (WRDA) to produce the comprehensive Study of the Lower Passaic River. The Study is an integrated, joint effort among the partner agencies to examine the ecosystem problems within the watershed and to identify remediation and restoration options to address these problems. Natural resource injuries are also being addressed in this comprehensive plan to the extent possible. The scope of the Study is to gather data needed to make decisions on:

- Remediating contamination in the river to reduce human health and ecological risks.
- Improving the water quality of the river.
- Improving and creating aquatic habitat.

- Improving human use.
- Reducing contaminant loading in the Lower Passaic River and the New York-New Jersey Harbor Estuary.
- Reducing future natural resource injuries.

This FFS was undertaken by the partner agencies to evaluate whether an early action could be implemented to control the sediments in the lower eight miles of the river, because they were identified as a major source of contamination to the Study Area. The FFS is being developed while the comprehensive Study is on-going.

1.3.2 CSM of the Lower Passaic River

A CSM[3] for the Study was initially presented in the August 2005 version of the *Work Plan* (Malcolm Pirnie, Inc., 2005b). This CSM has been updated as part of this FFS. A brief summary of conclusions discussed in Appendix A "Conceptual Site Model" is presented below.

The Lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around the Great Falls in Paterson, New Jersey. In subsequent years, a multitude of industrial operations developed along the banks of the Passaic River, as the cities of Newark and Paterson grew. These industrial operations included manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Moreover, the Lower Passaic River has been used as a major means of conveyance for municipal discharges from the middle of the nineteenth century to the present time. Ultimately, many contaminants were discharged to the Lower Passaic River, including 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), pesticides such as DDT, and heavy metals such as mercury and lead.

[3] A CSM expresses a site-specific contamination problem through a series of diagrams, figures, and narrative consistent with USEPA Office of Solid Waste and Emergency Response (OSWER) remedial investigation and feasibility study guidance (USEPA, 1988).

The Lower Passaic River is a partially stratified estuary where the degree of stratification and the location of the salt front at any point in time reflect a dynamic balance between the freshwater flow and the tidal exchange with Newark Bay. Tidal displacement in the Lower Passaic River is quite large, with the salt front moving several miles during each tidal cycle.

An important component of the region's development and urbanization was the deepening of the river to permit commercial vessels to travel to the city of Newark and farther upriver. Several large dredging projects were undertaken at the beginning of the twentieth century to create a navigation channel to approximately RM15. Since the 1940s, there has been little maintenance dredging above RM2. Consequently, extensive fine grained sediment deposits exist in the channel, particularly between RM2.5 and RM8. The coincidence of contaminant discharges to the river and a significant suspended sediment load created an ideal situation for accumulating contaminated sediments. As a result, the river accumulated substantial sediment beds, measuring up to 25 feet thick in some areas. These thick sediment deposits remain, primarily below RM8 where the relatively wider river channel provided favorable conditions for rapid sediment accumulation. Relatively little accumulation has occurred upstream of RM8 because of the narrower channel conditions. The change in river geometry is illustrated in Figure 1-3, which shows the relationship between location and the river's cross sectional area.

Despite the prevalence of thick sediment deposits below RM8, the sediments in this region are not all stable, and erosional areas have been identified throughout the lower 8 miles of the river. These erosional areas are believed to be responsible for on-going releases of contaminants from the river bed. This is shown in Figure 1-4, which plots the percentage of depositional and erosional area as a function of river mile. A detailed examination of sediment deposition rates between RM1 and RM7 indicates a high degree of spatial heterogeneity, with local rates varying from about 6 inches/year of erosion to about 8 inches/year of deposition. Historical deposition rates were probably higher than current rates because of the more extensive salt front intrusion and deeper channel depths immediately after the initial channel dredging, which would have enhanced settling of suspended sediment. A comparison of current and historical mass balances of solids coming into the Lower Passaic River shows that the relative importance of the solids load coming from the head-of-tide has increased over the years, compared to that coming from Newark Bay. The current head-of-tide solids load to the Lower Passaic River is greater than the annual average rate of accumulation in the river; however, the historical rates of sediment accumulation in the Lower Passaic River were probably too large to be sustained solely by the Passaic's head-of-tide solids loads, suggesting that solids transport from Newark Bay may have supplied the additional solids.

The CSM demonstrates that toxic constituent concentrations in the water column and biota of the Lower Passaic River are largely driven by contaminants contained within the sediments, particularly for 2,3,7,8-TCDD. While on-going external inputs may exist, the concentrations within the sediments are responsible for much of the contamination within the water column. In fact, the legacy of sediment contamination probably extends back at least to the mid-nineteenth century. The oldest contaminants found in the sediments are PAH compounds, cadmium, mercury, and lead, which probably pre-date the turn of the twentieth century. Following these contaminants are, in order of chronological appearance in the river, DDT; 2,3,7,8-TCDD; and PCB. Other contaminants, such as arsenic, chromium, and copper are also present in the sediment record. The vertical extent of these contaminants is illustrated schematically in Figure 1-5. The available evidence indicates that several of these compounds (*i.e.*, PAH, PCB, mercury, and lead) at least partially originated above the head-of-tide and Dundee Dam. Others, like 2,3,7,8-TCDD and DDT, are nearly exclusively the result of discharges to the Lower Passaic River.

Ratio analysis of several organic constituents has permitted the "fingerprinting" of the source material. Using these techniques, 2,3,7,8-TCDD contamination is shown to be derived almost exclusively from resuspension of legacy sediments (derived from historical industrial discharges) in the Lower Passaic River. PAH patterns indicate that the majority of PAH contamination in the sediments is derived from combustion-related processes, specifically coal tar residue (a by-product of manufactured gas plants) and urban background combustion, nearly all of which currently enters the Lower Passaic at Dundee Dam. Of these, coal tar wastes are historically the dominant source to the Lower Passaic River. For PCB, there are two main sources to the Lower Passaic River of roughly equal magnitude. The resuspension of legacy sediments contributes a mixture of low molecular weight PCB congeners while the flow from the Upper Passaic River (over the Dundee Dam) contributes a higher molecular weight PCB mixture.

One important observation from the extent of chemical contamination in the Lower Passaic River is the extent of tidal mixing throughout the river. Recently deposited sediments throughout the Lower Passaic River have very similar, and elevated, concentrations of contaminants, indicating that sediments are well homogenized prior to deposition. Thus, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history at that location and is generally not controlled by proximity to source. As a result, thick sequences of contaminated sediments will tend to have similar inventories of contaminants regardless of their location in the river.

The volume of contaminated fine-grained sediment is estimated at between 5 million and 8 million cubic yards for RM1 to RM7, with an average depth of contamination ranging from 7 to 13 feet. Extrapolating the contaminant sediment volume estimate into RM0 to RM1 and RM7 to RM8 increases the contaminated sediment volume estimate by approximately one-third, to between 6 million and 10 million cubic yards.

Contaminant inventories are not evenly distributed and vary along the length of the Lower Passaic River, with maximum values occurring near the areas encompassing RM1 to RM2, RM3 to RM4, and RM6 to RM7 (Figure 1-6). The coring data that form the basis for these inventories show a high degree of local spatial heterogeneity, indicating that localized areas of relatively higher concentrations typically described as "hot spots" may not exist. Instead, "hot zones" of the river seem to exist on the scale of a mile or more, nearly bank to bank (*i.e.*, the width of the navigation channel plus historical berth areas) in lateral extent. This conclusion does not, however, diminish the significance of potential historic or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. It is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) would identify localized gradients near prominent historical or current source areas.

The Lower Passaic River is a major source of contaminants to Newark Bay. Solids transport to Newark Bay delivers the contaminants found in surficial sediments, particularly 2,3,7,8-TCDD. It is estimated that the Lower Passaic River contributes approximately 10 percent of the total amount of solids accumulating in Newark Bay, and more than 80 percent of the 2,3,7,8-TCDD accumulating in the Bay. No other single source delivers more than 10 percent of the total 2,3,7,8-TCDD load. A similar mass balance analysis for mercury shows that, despite the high mercury concentrations in the sediments of the Lower Passaic River, the Lower Passaic River sediments are only responsible for approximately 20 percent of the total mercury load to Newark Bay (although 20 percent is not an insignificant contribution). Moreover, the known sources of mercury to Newark Bay cannot account for the annual accumulation of mercury in the sediment beds of the Bay. The "missing" mercury source represents the largest single "source" of mercury to Newark Bay, constituting approximately 35 percent of the annual mercury load.

In summary, although the Lower Passaic River is a partially stratified estuary, the tidal excursion is sufficiently energetic that the water column remains well-mixed with respect to suspended solids. Depositional rates in the Lower Passaic River are high due to historical dredging and subsequent re-filling due to reduced maintenance, and the combination of relatively well-mixed suspended matter and high deposition rates has yielded thick sequences of contaminated sediments. Local variations in sediment contaminant inventory are primarily attributed to variations in depositional rates, and not proximity to local sources; however, the resolution of available data sets is not sufficient to eliminate the possibility of very localized areas of high contaminant concentrations in the immediate vicinity of point sources. Surface concentrations in the Lower Passaic River are relatively homogeneous over long distances, with the range typically less than a factor of 3 along 12 miles or more of the river. Surface concentrations of many contaminants (*e.g.*, 2,3,7,8-TCDD) are maintained at high levels by resuspension of older, more contaminated sediments. Conversely, the concentrations of several important chemicals (*e.g.*, PAH) are driven by head-of-tide loads. Concentrations of some contaminants, such as PCB, are maintained by both head-of-tide influences and resuspension of legacy sediments.

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND SELECTION OF TARGET AREAS

This section of the FFS introduces the requirements that must be met by any remedial action, the objectives that remedial actions are designed to achieve, and the risk-based selection of a target area (or areas) for remediation. CERCLA requires the development of "...methods and criteria for determining the appropriate extent of removal, remedy, and other measures..." for responding to releases of hazardous pollutants and contaminants [CERCLA Section 105(a)(3)]. For the FFS, it was necessary to develop PRGs for sediment to allow a rigorous evaluation of the remedial alternatives for the Lower Passaic River. Because there are no chemical-specific ARARs pertaining to sediments (refer to Section 2.3 "Development of ARARs"), the PRGs considered consist of risk-based concentrations (RBCs) for fish tissue and sediment contaminants, as well as background sediment contaminant concentrations. This section describes the regulatory framework in which remediation goals were derived, the PRG development process, and the method used to identify background contaminant concentration to the estuary.

2.1 REMEDIAL ACTION OBJECTIVES

2.1.1 Overall Study Goals

Study goals have been developed by the partner agencies to establish the direction for the overall Study, which incorporates the CERCLA RI/FS to which this FFS pertains. These overall study goals are the basis to evaluate:

- Remediation of contaminated sediments.
- Improvement of water quality.
- Improvement and creation of aquatic habitat.
- Enhancement of human use.
- Reduction of contaminant loading in the Lower Passaic River and to the New York-New Jersey Harbor Estuary.

As an FFS for a Source Control Early Action, this effort is intended to address the first goal (*i.e.*, remediation of contaminated sediments) to the extent practicable, while contributing to achievement of the remaining goals prior to implementation of an overall remedy.

2.1.2 Remedial Action Objectives for the Source Control Early Action

RAOs provide a general description of what the cleanup is expected to accomplish and help focus the development of remedial alternatives in the FFS. RAOs specify the contaminants and media of concern, exposure routes and potential receptors, and an acceptable concentration limit or range for each contaminant for each of the various media, exposure routes, and receptors. RAOs are developed to set targets for achieving PRGs (ARARs and RBCs that are protective of human health and the environment) early in the remedial alternative development process. The RAOs should be as specific as possible, without unduly limiting the range of alternatives that can be developed. RAOs for the Lower Passaic River Source Control Early Action are as follows:

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of contaminants of potential concern (COPCs) in fish and shellfish.
- Reduce the risks to ecological receptors by reducing the concentration of contaminants of potential ecological concern (COPECs) in fish and shellfish.
- Reduce the inventory (mass) of COPCs and COPECs in sediments that is or may become bioavailable.
- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

It is implicit in the nature of an early action that potential actions should be suitable for implementation within a reasonable time period, consistent with the USEPA guidance on accelerated Superfund cleanups, *Introduction to Superfund Accelerated Cleanup Model* (USEPA, 1998b).

2.2 OVERVIEW OF ARARS

Section 121(d)(2) of CERCLA, as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), requires that on-site remedial actions comply with state and federal ARARs upon completion of the remedial action. Alternatively, certain requirements may be specifically waived by the Regional Administrator, if justified. The revised National Oil and Hazardous Substances Pollution Contingency Plan, otherwise known as the National Contingency Plan (NCP), requires compliance with ARARs during remedial actions as well as at completion.

The potential ARARs for the Study in each of the three categories [chemical-specific, location-specific, and action-specific (refer to Section 2.2.3 "Types of ARARs")] along with other TBC criteria, are summarized in Table 2-1 and discussed below. It should be noted that ARARs are potentially applicable in this FFS and become final upon issuance of the record of decision (ROD). The ARARs included here have been identified based on the alternatives considered and, depending upon the alternative ultimately selected, may not be included in a final decision document.

2.2.1 Definition of ARARs

ARARs consist of two sets of requirements: those that are applicable and those that are relevant and appropriate. Applicable requirements are those substantive standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those substantive standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a site, address problems or situations similar to those encountered at the site so as to be well-suited for use at the site.

On-site actions must attain those ARARs identified at the time of the ROD signature or provide grounds for invoking a waiver [CERCLA Section 121(d); 40 Code of Federal Regulations (CFR) Sections 300.430(f)(ii)IB) and 300.435(b)(2)]. The NCP defines ARARs as substantive requirements, criteria or limitations. In contrast, procedural requirements such as permit applications, reporting, record keeping and consultation with administrative bodies are not ARARs. CERCLA specifies that no federal, state or local permits are required for on-site response actions [CERCLA Section 121(e)]. Although consultation with the state and federal offices responsible for issuing the permits is not required, it is recommended for compliance with the substantive requirements. Permits must be obtained for all response activities conducted off-site. Off-site actions must comply with both the substantive and administrative parts of those requirements.

2.2.2 "To Be Considered" Information

Many federal and state environmental and public health agencies develop criteria, advisories, guidance, and proposed standards that are not legally enforceable, but contain information that would be helpful in carrying out, or in determining the level of protectiveness of, selected remedies. TBC materials are meant to complement the use of ARARs, not compete with or replace them. Because TBCs are not ARARs, their identification and use are not mandatory.

Where no ARARs exist to address a particular situation, the TBCs may be used to set cleanup targets (in conjunction with a baseline risk assessment). Many ARARs have broad performance criteria but do not provide specific instructions for implementation. Often, these instructions are contained in supplemental program guidance that may be considered a TBC.

2.2.3 Types of ARARs

Any substantive environmental requirement has the potential to be an ARAR. A substantive requirement typically specifies a level or standard of control, although it could also provide performance criteria or location restrictions. To simplify the universe of such requirements, USEPA divides ARARs into three categories to facilitate identification:

- Chemical-Specific ARARs: These are either health- or risk-based numerical values or methodologies that establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment. Where more than one requirement addressing a contaminant is determined to be an ARAR, the most stringent requirement should be applied, unless it is waived by the Regional Administrator.
- Location-Specific ARARs: These are restrictions of certain activities based on the concentration of hazardous substances solely because of geographical or land use concerns. Requirements addressing wetlands, historic places, floodplains, or sensitive ecosystems and habitats are potential location-specific ARARs.
- Action-Specific ARARs: These requirements set restrictions on the conduct of certain activities or operation of certain technologies at a particular site, and are primarily used to assess the feasibility of remedial technologies and alternatives. Regulations that dictate the design, construction, and operating characteristics of incinerators, other treatment units, or landfills are examples of action-specific ARARs.

2.2.4 Waiver of ARARs

CERCLA Section 121(d) provides that under certain circumstances an ARAR may be waived. The six statutory waivers are as follows:

- Interim Measure: occurs when the selected remedial action is only part of a total remediation action that will attain ARARs when completed.

- Greater Risk to Health and the Environment: occurs when compliance with such requirements will result in greater risk to human health and the environment than the alternative options.
- Technical Impracticability: occurs when compliance with such requirements is technically impracticable from an engineering perspective.
- Equivalent Standard of Performance: occurs when the selected remedial action will provide a standard of performance equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation through use of another method or approach.
- Inconsistent Application of State Requirements: occurs when a state requirement has been inconsistently applied in similar circumstances at other remedial actions within the state.
- Fund-Balancing: occurs when, in the case of an action undertaken using Superfund resources, the attainment of the ARAR would entail extremely high costs relative to the added degree of reduction of risk afforded by the standard such that remedial actions at other sites would be jeopardized.

2.3 DEVELOPMENT OF ARARS

Chemical-specific, location-specific, and action-specific ARARs and TBCs are considered in the development and evaluation of remedial alternatives. When an alternative is selected, it must be able to fulfill the requirements of all ARARs (or a waiver must be justified). Table 2-1 (attached) provides a compilation of the ARARs and TBCs identified for this FFS in consultation with the Partner Agencies. Also included in Table 2-1 (attached) are brief descriptions of the cited requirements and summaries of the actions, discharges, or processes resulting from the project activities to which the ARARs and TBCs may apply.

2.3.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs define concentration limits or other chemical levels for environmental media. Based on the RAOs for the Source Control Early Action FFS

(Section 2.1.2 "Remedial Action Objectives for the Source Control Early Action"), only requirements for sediment are considered here. There are no ARARs for sediments.

A broad universe of potential chemical-specific TBCs was initially identified from criteria developed by other USEPA regions and a variety of other agencies (Appendix B "Sediment TBCs and Development of Preliminary Remediation Goals"). Appendix B Table B-1 presents a detailed inventory of these potential TBCs and their sources while Table B-2 lists the associated contaminant screening values. As described in Section 2.4 "Development of Preliminary Remediation Goals," PRGs were developed for the FFS. These PRGs, while not ARARs, are concentration limits that have been developed specifically for the Source Control Early Action based on site-specific RBCs. They are thus considered to be more appropriate benchmarks for Early Action at the site than any of the initially identified chemical-specific TBCs. As a result, all of the potential chemical-specific TBCs were screened from consideration as viable criteria for the Early Action.

2.3.2 Location-Specific ARARs and TBCs

The following location-specific ARARs were identified for the FFS:

- Endangered Species Act, 16 United States Code (U.S.C.) §1536; 50 CFR §402 Subpart B: Broad protection is provided for species of fish, wildlife, and plants that are listed as threatened or endangered in the United States or elsewhere.
- Federal Consistency Determination, 15 CFR § 930.36: The Federal Consistency Determination requires that federal agencies review their activities to determine whether such activities will be undertaken in a manner consistent to the maximum extent practicable with the enforceable policies of approved management programs.
- Freshwater Wetlands Protection Act Rules, New Jersey Administrative Code (N.J.A.C.) 7:7A-4.3: The Act regulates activities in freshwater wetlands, such as excavation, drainage, discharge of material, driving pilings, placing obstructions to flow, and destruction of plant life. The process for delineating a wetland and determining the width of the transition zone is specified, and wetland mitigation requirements are presented.

- National Historic Preservation Act (NHPA), 16 U.S.C. §470 et seq.; 36 CFR. Part 800: The NHPA requires consultation to identify historic properties potentially affected by federal activities and to assess the effects and to seek ways to avoid, minimize or mitigate any adverse impacts to those identified properties.
- Soil Erosion and Sediment Control Act regulations, N.J.A.C. 7:13-3.3: These regulations require controls for soil erosion and sediment prior to commencing any land development projects.
- Flood Hazard Control Act, N.J.S.A. 15:16A-50, et seq.: These regulations cover stream encroachment activities and development in floodways and flood fringes. Designs must prevent obstruction of flow or change in flow velocity in the case of a flood. Evaluations are ongoing to determine the applicability of these regulations.

The following location-specific TBC was identified for the FFS:

- NJDEP Soil Cleanup Criteria. [Contaminant Values for Residential Direct Contact Soil Cleanup Criteria, Non- Residential Direct Contact Soil Cleanup Criteria, and Impact to Ground Water Soil Cleanup Criteria; last revised May 12, 1999 (Note that NJDEP proposed new Soil Cleanup Criteria in May 2007; the final rule is planned to be promulgated after a public comment period ending July 27, 2007.)] The NJDEP soil cleanup criteria will be utilized for determining the appropriateness of using dredged sediments, or treated dredged sediments, for other beneficial land application uses within the State of New Jersey.

2.3.3 Action-Specific ARARs and TBCs

The following action-specific ARARs are identified for the FFS:

- Rivers and Harbors Act, 33 U.S.C. § 403: Activities that could impede navigation and commerce are prohibited without authorization from the Secretary of the Army. Such activities include obstruction or alteration of any navigable waterway, building of bulkheads outside harbor lines and any excavation or fill in navigable waters. In accordance with CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are conducted entirely on site, although remedial actions must comply with the substantive requirements of the Rivers and Harbors Act.

- Section 404 of the Clean Water Act (CWA), 40 CFR Parts 321, 322, and 323: The CWA includes requirements for the discharge of dredged or fill material into navigable waters of the United States. The Act also regulates the construction of any structure in navigable waters.
- Resource Conservation and Recovery Act (RCRA), 40 CFR. § 261, 262, 264, 265, and 268: Dredged material may be subject to RCRA regulations if it contains a listed waste, or if it displays a hazardous waste characteristic based on the Toxicity Characteristic Leaching Procedure (TCLP) test. RCRA regulations may potentially be ARARs for the storage, treatment, and disposal of dredged material unless an exemption applies. If dredged material is removed but replaced in water within the Area of Contamination, which for this FFS includes the Lower Passaic River, Newark Bay and areal extent of contamination, RCRA land disposal regulations (LDR) are not triggered.
- Toxic Substances Control Act (TSCA), 40 CFR. § 761: TSCA regulates PCBs from manufacture to disposal. Remediation of sediments with PCB concentrations greater than 50 milligrams per kilogram of sediment (mg/kg) or part per million (ppm) is considered PCB waste remediation and is controlled under TSCA.
- Hazardous Materials Transportation Act, 49 CFR. § 107, 171, 172 and potentially 174, 176, or 177: United States Department of Transportation rules apply to the transportation of hazardous materials, and include the procedures for the packaging, labeling, manifesting, and transporting of hazardous materials.
- Stormwater Management Rules, N.J.A.C. 7:8-2.2 and Subchapter 5: These regulations establish the design and performance standards for stormwater management measures.
- Water Quality Certification, Section 401 of the CWA, 33 U.S.C § 1341: The CWA requires that applications for permits and licenses for any activity resulting in a discharge to navigable water include certification that the discharge will comply with applicable water quality and effluent standards. In accordance with CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are

conducted entirely on site, although remedial actions must comply with the substantive requirements of CWA Section 401.

- New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A, (Subchapters 4.4, 5.3, 6.2, 11.2, 12.2, 13, 21.2 and Appendix B of chapter 12): This chapter regulates the direct and indirect discharge of pollutants to the surface water and ground water of New Jersey. It presents a list of effluent standards for site remediation projects, and includes rules for land application permits, residual transfer stations, and stormwater discharge information. In accordance with CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are conducted entirely on site, although remedial actions must comply with the substantive requirements of the NJPDES rules.
- New Jersey Technical Requirements for Site Remediation, N.J.A.C 7:26E-1.13, -2.1, -2.2, -3.4, -3.8, -3.11, -4.5 and -4.7: These regulations identify the minimum technical requirements that must be followed in the investigation and remediation of any contaminated sites in New Jersey. Both numeric and narrative standards for remediation of groundwater and surface water are listed.
- Federal/State Pretreatment Standards, 40 CFR. § 403, and more stringent requirements enacted by State or local law: These standards provide pretreatment criteria that waste streams must meet prior to discharge to Publicly Owned Treatment Works (POTW).
- National Ambient Air Quality Standards (40 CFR. § 50): The Clean Air Act requires USEPA to set standards for pollutants considered harmful to public health and the environment. Standards are established for six primary and secondary pollutants.
- New Jersey Air Pollution Control Rules, N.J.A.C. 7:27: The chapter governs emissions that introduce contaminants into the ambient atmosphere for a variety of substances and from a variety of sources.

2.4 DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

Generally, PRGs that are protective of human health and the environment are developed early in the RI process based on readily-available screening levels for human health and ecological risks. Since there are no chemical-specific ARARs that pertain to sediments, risk-based concentrations that are protective of fish consumption and associated concentrations in sediment, that are protective of benthic organisms and wildlife, and based on background concentrations were developed for this FFS.

2.4.1 Human Health Preliminary Remediation Goals

Human Health PRGs were developed consistent with *USEPA Risk Assessment Guidance for Superfund (RAGS) Part B* (USEPA, 1991b) and based on the results of the human health risk assessment (HHRA) presented in Appendix C "Risk Assessment." The process used to identify contaminants of potential concern (COPCs) and contaminants of potential ecological concern (COPECs) is described in Attachment 4 of Appendix C. Details on PRG development methods, data, and assumptions are presented in Appendix B "Sediment TBCs and Development of Preliminary Remediation Goals." Human health PRGs were developed for COPCs with individual cancer risks above 10^{-4} (*i.e.*, one in 10,000):

- PCDD/F as toxic equivalent quotient (TEQ) [TCDD TEQ (D/F)].
- PCB as Total PCB (sum of Aroclors).
- PCB dioxin-like congeners evaluated as TCDD TEQ (PCB).

PRGs were also developed for COPCs with individual noncarcinogenic health hazards above a hazard index (HI) of 1.0:

- Total PCB (sum of Aroclors).
- Total Chlordane.
- Methyl mercury.

The methods, data, and exposure assumptions used to calculate the risk-based PRGs for the protection of human health are described in Appendix B "Sediment TBCs and Development of Preliminary Remediation Goals." The PRGs developed for the adult angler who consumes fish or crabs from the Lower Passaic River are summarized in Table 2-2. For the analysis, the point of departure for cancer risks was calculated at 10^{-6}

(*i.e.*, one in a million) and for non-cancer health hazards the point of departure was a HI equal to 1.

Table 2-2: Summary of the PRGs Developed for Fish/Crab Tissue

COPC	PRGs[a] for Fish/Crab Tissue for an Adult Angler			
	Cancer PRGs (ng/g)			Non-cancer PRGs (ng/g)
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	
TCDD TEQ	0.000055	0.00055	0.0055	ND[b]
Total PCB	4.1	41	410	56
Chlordane	23	230	2,300	1,407
Methyl mercury	ND[c]			281

ng/g – nanograms per gram of sediment
ND – not determined.
a: Assumes 40 eight-ounce fish or crab meals per year for 24 years.
b: No toxicity values are available at this time.
c: Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

When available data indicate that a COPC is associated with both carcinogenic and noncarcinogenic health hazards, as is the case for Total PCB, PRGs were calculated for both. Since PCBs have both carcinogenic risk and non-cancer health hazards, both health endpoints are considered in selecting the PRGs. Based on the available toxicity data, a PRG based on carcinogenic effects was calculated for Total PCB, but not for the TCDD TEQ (PCB), because: (1) the estimated risks for Total PCB and TCDD TEQ (PCB) are comparable, so that calculated PRGs using Total PCB and coplanar PCB congeners separately would not significantly differ; and (2) any remedial action based on total PCB PRGs would address the presence of the dioxin-like PCB congeners based on co-location.

The fish-tissue PRGs presented in Table 2-2 were based on an adult fish consumption rate of 25 g/day or 40 eight-ounce fish meals per year. Appendix B “Sediment TBCs and Development of Preliminary Remediation Goals” discusses PRGs calculated for other fish-meal frequencies associated with New Jersey fish consumption advisory levels.

Sediment concentrations required for fish to meet the risk-based concentration levels were estimated by dividing the tissue concentrations by a chemical-specific bioaccumulation factor (BAF). The estimated risk-based sediment concentrations are presented in Table 2-3. BAFs were derived as the ratio of biota (*i.e.*, fish and crab) tissue concentration to sediment concentration. A detailed description of how the BAFs were derived is provided in Section 7.0 of Appendix C "Risk Assessment."

Table 2-3: Summary of the PRGs Developed for Sediment

COPC	PRGs[a] for Sediment			
	Cancer PRGs (ng/g)			Non-cancer PRGs (ng/g)
	1×10^{-6}	1×10^{-5}	1×10^{-4}	
2,3,7,8-TCDD	0.00027	0.0027	0.027	ND[b]
Total PCB	1.03	10.3	103	14
Chlordane	1.2	12.0	119	72
Mercury	ND[c]			2,814

ND – not determined.
a: Assumes 40 eight-ounce fish or crab meals per year for 24 years.
b: No toxicity values are available at this time.
c: Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

2.4.2 Ecological Preliminary Remediation Goals

Ecological risk PRGs were developed consistent with USEPA Risk Characterization Program (USEPA, 1997) and based on the results of the ecological risk assessment (ERA) presented in Appendix C "Risk Assessment." Sediment and fish tissue ecological PRGs were developed for all COPECs identified in the FFS COPEC screening process documented in Attachment 4 of Appendix C "Risk Assessment". COPECs include copper, lead, mercury (including methyl mercury), low-molecular weight PAH (LPAH) and high-molecular weight PAH (HPAH), Total PCB (sum of Aroclors), Total DDx [sum of dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and (dichlorodiphenyltrichloroethane) DDT isomers], dieldrin, TCDD TEQ (D/F),[4] , and PCB dioxin-like congeners evaluated as TCDD TEQ (PCB).

The methods, data, and assumptions used to calculate the ecological receptor PRGs are described in detail in Appendix B "Sediment TBCs and Development of Preliminary Remediation Goals." Table 2-4 presents the ecological PRGs for the selected sediment

[4] Consistent with the Toxic Equivalency approach (Tillitt, 1999), the toxicological basis for the PRGs for PCDD/F and coplanar PCB compounds is 2,3,7,8-TCDD. TCDD TEQ refers to the combined equivalency associated with all Aryl hydrocarbon receptor (AhR) mediated toxicity.

COPECs for each category of receptor considered in the ERA. The overall ecological PRG is the lower of the two values. The fish tissue PRGs presented in Table 2-5 include results of the residue-based (fish) and dose-based (wildlife) analyses conducted as part of the ERA.

Table 2-4: Summary of Sediment PRGs for Ecological Receptors

Chemical	Units	Sediment PRGs		Lowest
		Benthos[a]	Wildlife[b]	
Inorganics				
Copper	ng/g	34,000	13,318	Wildlife PRG
Lead	ng/g	46,700	10,606	Wildlife PRG
Mercury	ng/g	150	37	Wildlife PRG
PAHs				
Low Molecular Weight PAHs	ng/g	552	-	NOAA ER-L
High Molecular Weight PAHs	ng/g	1700	-	NOAA ER-L
PCB Aroclors				
Total PCBs	ng/g	22.7	365	NOAA ER-L
Pesticides/Herbicides				
DDx	ng/g	1.58	19	NOAA ER-L
Dieldrin	ng/g	0.02	271	NOAA ER-L
Dioxins/Furans				
TCDD TEQ[c]	ng/g	0.0032	0.0025	Wildlife PRG

q: ER-L = Effects Range-Low from Long *et al.* (1995), except where noted.
b: Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix B).
c: Benthic benchmark for 2,3,7,8-TCDD derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper (2003); wildlife value from USEPA (1993).

Table 2-5: Summary of Fish Tissue PRGs for Ecological Receptors

Chemical	Units	Fish Tissue PRGs		Lowest
		Fish[a]	Wildlife[b]	
Inorganics				
Copper	ng/g	6.3	21,935	Fish
Lead	ng/g	88	700	Fish
Mercury	ng/g	19	40	Fish
PAHs				
Low Molecular Weight PAHs	ng/g	89	-	Fish
High Molecular Weight PAHs	ng/g	89	-	Fish
PCB Aroclors				
Total PCBs	ng/g	7.9	676	Fish
Pesticides/Herbicides				
DDx	ng/g	0.3	147	Fish
Dieldrin	ng/g	35	487	Fish
Dioxins/Furans				
TCDD TEQ[c]	ng/g	0.050	0.0007	Wildlife

a. Based on critical body residuals (CBRs) as summarized in Appendix C "Risk Assessment".
b. Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix C, Attachment 2); lowest of mammal and avian values.
c. Low risk fish concentrations for 2,3,7,8-TCDD from USEPA (1993).

2.4.3 Identification of Background Concentrations

According to contaminated sediment remediation guidance, project managers should consider background contributions to sites to adequately understand contaminant sources and establish realistic risk reduction goals (USEPA 2005). The contaminated sediments in the Lower Passaic River are located within a setting of interconnected waterways, including the Passaic River above the Dundee Dam, tidal exchanges with Newark Bay, and tributaries. These interconnected waterways need to be evaluated because they could continue to contribute contaminants to the Lower Passaic River following the implementation of a remedial alternative. This is particularly relevant to the achievement of remediation goals (*e.g.*, long-term effectiveness and permanence), since USEPA (2002b) stipulates that "… the CERCLA program, generally, does not clean up to concentrations below natural or anthropogenic background levels."

The *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, 2006) examined sediment contaminant concentration gradients from the mouth of the Lower Passaic River into the Newark Bay Study Area (NBSA). Sediment contaminant concentrations generally decrease by an order of magnitude from north to south, from the Lower Passaic River into the NBSA. These data indicate that tidal exchange between the Lower Passaic River and NBSA currently results in the net transport of contaminants from the Lower Passaic River to Newark Bay. The NBSA RI/FS itself was initiated based on the concern that contaminants related to the 80 Lister Avenue site on the Lower Passaic River had impacted Newark Bay (USEPA 2004). Remediation of sediment contamination in the Lower Passaic River is expected to reduce these impacts, causing sediment contaminant concentrations in the NBSA to subsequently trend towards the concentrations of solids transported into the NBSA from the Arthur Kill and the Kill Van Kull. From this it can be inferred that NBSA sediments (and by extension, New York Harbor sediments) are too closely related to contamination in the Lower Passaic River to be considered as a potential "background" for the FFS.

Investigation of sediment contaminant concentrations in the Upper Passaic River above the Dundee Dam has revealed the presence of historic and ongoing upstream sources of inorganics, pesticides, and Total PCB that are significant in comparison to contaminant concentrations in the Lower Passaic River. USEPA (2002b) defines "background" as constituents and locations that are not influenced by releases from the site and includes both anthropogenic and naturally derived constituents. The physical boundary of the dam isolates the proximal Dundee Lake and other Upper Passaic River sediments from any Lower Passaic River influences. The proximity of these sediments to the proposed remediation area and demonstrated geochemical connection to a portion of the Lower Passaic River sediment contamination strongly argues in favor of their consideration as representative of "background" for the Lower Passaic River. The chemistry in these sediments is representative of the burden carried by the Upper Passaic River's suspended solids; therefore the deposited sediments record the background load to the Lower Passaic River. The Role of Background in the CERCLA Cleanup Program (USEPA, 2002b) explains that CERCLA sites generally do not set cleanup levels below acknowledged anthropogenic-derived COPC and COPEC background concentrations. In cases where background contamination may pose risks, other programs or regulatory authorities may be appropriate to address the sources, particularly those that are anthropogenic.

Table 2-6 lists the concentrations of COPC and COPEC detected in a sediment core top collected above Dundee Dam. Using geochemical principles discussed in Appendix A "Conceptual Site Model," the chemicals found in the core top are interpreted to represent the current water column solids contaminant concentrations being introduced to the Lower Passaic River from the Upper Passaic River. The chemical mass contributed with the solids load from the Upper Passaic River represents a significant source of all of the COPCs and COPECs, except 2,3,7,8 TCDD, and can be considered the background to the Lower Passaic River.

Table 2-6: Background COPEC and COPC Concentrations

	Units	2007 (Background)
Inorganics		
Copper	ng/g	80,000
Lead	ng/g	140,000
Mercury	ng/g	720
PAHs		
LPAH	ng/g	8,900
HPAH	ng/g	65,000
PCB Aroclors		
Total PCB	ng/g	650
Pesticides/Herbicides		
Total DDx	ng/g	91
Dieldrin	ng/g	4.3
Chlordane	ng/g	92
PCDD/F		
2,3,7,8-TCDD	ng/g	0.002

Because of this contaminant load, any remedial effort within the Lower Passaic River can only be expected to meet the risk-based PRGs once the load from above the dam also meets the PRGs. The load from the Upper Passaic River can be considered a baseline that represents the maximum concentration that would be expected in the post-remediation Lower Passaic River (dilution from other, less-contaminated sediment sources would cause the concentrations in the Lower Passaic River to be less than what is contributed over the dam).

2.4.4 PRG Selection

A single PRG for each contaminant was selected to guide the analysis of target areas and alternatives for remediation using the nine Superfund evaluation criteria. In accordance with EPA risk assessment guidance (Part B, Development of Risk-Based Preliminary Remediation Goals, USEPA 1991), the point of departure for the selection of PRGs is a risk level of 10^{-6} and a non-cancer Hazard Index = 1 for protection of human health and the lower of the two ecological PRGs set to protect benthic organisms and wildlife at a hazard quotient of one. However, EPA guidance entitled "Role of Background in the CERCLA Cleanup Program (USEPA, 2002b) provides that "… the CERCLA program, generally, does not clean up to concentrations below natural or anthropogenic background levels." As presented in Table 2-7 (attached), current background levels for all of the contaminants are above the human health PRG that represents the 10^{-6} risk level, non-cancer Hazard Index = 1, and the lower ecological PRG (or as many of these values which have been developed). Therefore, the target areas and alternatives will be evaluated against the current background levels as represented by the recently deposited sediments from a core collected from the Upper Passaic River in the stretch immediately above Dundee Dam.

However, as discussed in Table 2-7, the background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action will need to be implemented above Dundee Dam to identify and reduce or eliminate those background sources. Such a separate action might include identifying facilities above the dam with on-going contributions to the Upper Passaic River, or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or State of New Jersey regulatory programs.

2.5 IDENTIFICATION OF POTENTIAL TARGET AREAS FOR REMEDIATION

When developing remedial alternatives, it is necessary to identify the sediments that might be appropriately targeted for remediation to meet the RAOs. Criteria for making this identification typically include ARARs, RBCs, and PRGs, as well as geochemical and statistical interpretations of contaminant concentration data and sediment characteristics. The six active remedial alternatives (aside from the No Action alternative) developed in Section 4.0 "Development of Remedial Action Alternatives" will be applied to the target area identified below.

2.5.1 Target Area Identification Analyses

In an effort to identify distinct areas that, if remediated, may result in the achievement of RAOs, a series of geospatial and geochemical analyses were conducted as described below. More information on the methodologies used and the results obtained for each of the analyses is presented in Appendix A "Conceptual Site Model."

2.5.1.1 Primary Erosional Zone

As discussed in the CSM, tidal currents continuously cause surface sediments to resuspend. Once suspended, sediments are significantly homogenized prior to deposition. Given these observations, an analysis was conducted to attempt to discern the existence of highly erosive areas which might have relatively greater influence on the nature, extent, and/or degree of contamination present in suspended sediments.

Data obtained during eight bathymetric surveys conducted between 1989 and 2004 were used to generate eight interpolated surfaces, each representing the sediment surface at the time of a survey. These surfaces were then compared against one another, and information was obtained regarding the net annual rate of erosion and deposition in the surveyed areas during the timeframe encompassed by the surveys. The results of this comparison identified certain bands within the Area of Focus which were consistently or occasionally erosional on a net annual basis during the timeframe encompassed by the surveys. The results of this comparison are shown in Figure 2-1.

A plot of river mile versus the proportion of area that is consistently or occasionally erosional is shown in Figure 2-2. Inspection of this plot shows that the major peaks (*i.e.*, where the proportion of area that is consistently or occasionally erosional is greater than 10 percent) are found between RM3.7 and RM5.3 (RI/FS RM3.5 and RI/FS RM5.1). A boundary was drawn around the consistently and occasionally erosional areas within these limits to define the Primary Erosional Zone. This boundary was adjusted based on engineering judgment to create an area amenable to potential remedial actions. The total area of the Primary Erosional Zone is approximately 68 acres.

2.5.1.2 Primary Inventory Zone

As discussed in the CSM, contamination in the Area of Focus is well mixed. At any time horizon within the sediment bed, concentrations are constrained within a narrow range regardless of location. With this characteristic in mind, the variation in contaminant inventory from one location to another is influenced more by the difference in thickness of the sediment deposit than by any difference in the magnitude of contaminant concentrations at either location.

The metric of mass per unit area (MPA) is a measure of the mass of a contaminant contained beneath a unit area of the sediment surface, and typically has units of grams per square meter. For the purposes of this evaluation, given the well-mixed nature of contamination, MPA is considered a suitable metric to quantify inventory at a given location. Calculations of MPA for coring locations throughout the river were presented in the *Draft Geochemical Evaluation (Step 2)* (Malcolm Pirnie, Inc., 2006) and are discussed in Appendix A "Conceptual Site Model."

In order to determine if certain areas in the river contain a relatively higher amount of inventory, a plot of river mile versus weighted curve sediment inventory was prepared (Figure 2-3). From this plot, it can be seen that the area between RM2.6 and RM3.5 (RI/FS RM2.4 and RI/FS RM3.3) contains the highest inventory for the contaminants analyzed. A boundary created around these limits was adjusted based on engineering judgment to identify an area amenable to potential remedial actions. This area, which is referred to as the Primary Inventory Zone, covers approximately 63 acres.

2.5.1.3 Area of Focus

As discussed in Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas," risk reduction anticipated to result from remediation of either the Primary Inventory Zone, Primary Erosional Zone, or both were not adequate; hence, the Area of Focus is selected. This includes the entire (bank-to-bank) river area from RM0 to RM8.3 (RI/FS RM8.0), which contains elevated COPC and COPEC concentrations in surface sediment and contaminant inventory that is at risk of being eroded and transported over time due to high flow events as well as typical flow and tidal conditions. This contaminant transport is likely to interfere with natural recovery of the Lower Passaic River and Newark Bay and other contiguous water bodies. The Area of Focus encompasses both the Primary Erosional Zone and the Primary Inventory Zone, and the remaining fine-grained sediment below RM8. As discussed in Appendix A "Conceptual Site Model," there is a natural constriction in the Lower Passaic River at about RM8 and the river widens and slows considerably downriver of that point. For these reasons the majority of fine-grained sediment exists below this point. Small areas of fine-grained sediment accounting for about 11 percent of the total fine-grained sediment area do occur above RM8. However, these deposits are much thinner than the sediments below RM8 and represent much smaller risk than the fine-grained sediment deposit below RM8. The Area of Focus covers approximately 650 acres.

2.5.2 Estimation of Future Concentration in Surface Sediments

Future concentrations of COPCs and COPECs in the Lower Passaic River surface sediments were estimated using an empirical method. First an empirical mass balance was developed to quantify the contributions of the various solids and contaminant sources to the sediment present in the Lower Passaic River, such as sediment re-suspension, the Upper Passaic River, tributaries, CSOs/SWOs, and tidal exchange with Newark Bay.

For several of the COPCs and COPECs, simple forecasting was sufficient to estimate the future concentration. "Simple forecasting" entails an examination of contaminant levels in the dated sediment cores (high resolution cores) over the period approximately 1980 to 2005 to establish an approximate rate of decline (usually expressed as an exponential decay rate, or half-life). This rate of decline, or trajectory, was then assumed to hold indefinitely into the future as a basis to estimate future sediment concentrations. For Monitored Natural Recovery (MNR), simply projecting the concentration decline curve into the future predicts the concentration at a given time. For remedial scenarios, the rate of decline was applied to a revised estimate of COPC and COPEC concentrations surface sediment based on the empirical mass balance, adjusted for the remedial scenario (*e.g.*, capping of the Area of Focus reduces the resuspension contribution to the overall contamination). The estimate of the amount of reduction is dependent on the relative proportions of the contaminant in the subsurface sediments of the Lower Passaic River and in the various external solids sources as determined by the mass balance. The empirical mass balance and contaminant concentration projections are described in detail in Appendix D "Empirical Mass Balance Model" and Table 2-8.

Table 2-8: Prediction Process for Concentrations in Surface Sediment for the Risk Assessment

Compound	Forecast Basis
Metals	
Copper	Simple forecast.
Lead	Simple forecast.
Mercury	Simple forecast.
PAHs	
LPAH	Simple forecast (note that current observations suggest no trend or a slightly increasing trend with time).
HPAH	Simple forecast (note that current observations suggest no trend or a slightly increasing trend with time).
PCB	
Total PCB (sum Aroclors)	Simple forecast of the sum of PCB congeners as a surrogate for the sum of Aroclors. The ratio of the sum of PCB congeners to the sum of Aroclors was based on an analysis of the 2006 USEPA low resolution core data.
TCDD TEQ (PCBs)	Simple forecast of the sum of congeners as a surrogate for the sum of PCBs with TCDD TEQs. The ratio of the sum of congeners to the sum PCB TEQ was based on an analysis of the 2006 USEPA high resolution core data. For the MNR scenario, this ratio was assumed to remain unchanged with time. For the remedial scenarios, the PCB TEQ for the major solids sources (Dundee Dam and possibly Newark Bay) was examined to estimate a PCB TEQ ratio for the Lower Passaic River after remediation. Once established post-remediation, this ratio is assumed to be unchanged with time and the PCB TEQ simply tracks the sum of PCB congeners forecast.
Pesticides/Herbicides	
Chlordane	Simple forecast (note that current observations suggest no trend or a slightly increasing trend with time).
Dieldrin	Simple forecast (note that current observations suggest no trend or a slightly increasing trend with time).
4,4'-DDE	Simple forecast.
4,4'-DDD	A simple forecast of DDE as a surrogate for DDD. The ratio of DDD to DDE was based on an analysis of the 2005 USEPA high resolution core data. Alternatively, the sum of DDD and DDE was checked as an alternative basis for forecasting.
4,4'-DDT	A simple forecast of DDE as a surrogate for DDT. The ratio of DDT to DDE was based on an analysis of the 2005 USEPA high resolution core data.
Total DDx	A simple forecast of DDE as a surrogate for Total DDx. The ratio of Total DDx to DDE was based on an analysis of the 2005 USEPA high resolution core data.
PCDD/F	
TCDD TEQ (D/F)	A simple forecast of 2,3,7,8-TCDD as a surrogate for the TCDD TEQs. The ratio of 2,3,7,8-TCDD to the sum TCDD TEQs was based on an analysis of the 2005 USEPA high resolution core data. For the MNR scenario, this ratio was assumed to remain unchanged with time. For the remedial scenarios, the TCDD TEQ for the major solids sources (Dundee Dam and possibly Newark Bay) were examined to assess whether an alternate TCDD TEQ ratio will exist in the Lower Passaic River after remediation. Once established post-remediation, this ratio was assumed to be unchanged with time and the TCDD TEQ trajectory simply tracks the 2,3,7,8-TCDD forecast.

Table 2-9 presents the projected concentrations in 2048 for the No Action alternative, for active remediation of the Area of Focus, and for active remediation of the Primary Erosional Zone and Primary Inventory Zone. Table 2-9 also presents percent reductions between 2018 and 2048. The year 2018 is an assumed completion of remediation date, approximately ten years from the time of writing this document. Table 2-10 shows the predicted COPC and COPEC concentrations in 2048 in comparison to the Upper Passaic River background concentrations.

Table 2-10: Forecasted Concentrations in Surface Sediment Compared to Background Concentrations from the Upper Passaic River

Analyte	Upper Passaic River Sediment Background Concentrations	Forecasted 2048 Concentration Primary Erosion Zone	Forecasted 2048 Concentration Area of Focus
Mercury (mg/kg)	0.72	0.22	0.17
Lead (mg/kg)	140	65	60
Copper (mg/kg)	80	41	38
Total Chlordane (μg/kg)	92	36	36
DDE (μg/kg)	26	8.0	5.7
DDD (μg/kg)	59	11	7.9
DDT (μg/kg)	6.8	2.4	1.7
Total DDT (μg/kg)	91	22	15
Dieldrin (μg/kg)	4.3	3.9	3.4
2,3,7,8-TCDD (ng/kg)	2.0	32	6.5
PCDD/F TEQ (μg/kg)	0.002	0.032	0.0066
Total PCB (μg/kg)	660	84	64
PCB TEQ Mammal (μg/kg)	0.014	0.0017	0.0013
PCB TEQ Bird (μg/kg)	0.151	0.026	0.020
PCB TEQ Fish(μg/kg)	0.001	0.00014	0.00011
LMW PAH (mg/kg)	8.9	5.3	5.2
HMW PAH (mg/kg)	65	35	35

Concentrations rounded to two significant figures, whenever possible

2.6 RISK REDUCTION RESULTING FROM REMEDIATION OF IDENTIFIED TARGET AREAS

2.6.1 Human Health Risk Assessment Summary

The HHRA evaluated potential risk to human health from eating fish and crab. The HHRA is presented in detail in Appendix C "Risk Assessment." Cancer risks and non-cancer health hazards were evaluated for a RME to assist in the decision-making process, consistent with the NCP (USEPA, 1990). For purposes of establishing current risks and comparing the relative risk reductions after remedial alternatives are implemented, cancer

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risks were estimated for a combined adult/child receptor (6 years as a child and 24 years as an adult) and non-cancer health hazards were estimated for a child and adult receptor. The exposure duration for the combined adult/child of 30 years is used to represent the most conservative standard receptor for evaluation of carcinogens. The cancer risks derived in the HHRA are compared to the NCP risk range of 10^{-4} (one in ten thousand) to 10^{-6} (one in a million) and non-cancer threshold of 1 (USEPA, 1991b). The HHRA used the same set of COPCs and the same risk assessment methodology, including potential exposure scenarios and assumptions that were evaluated in the current risk evaluation described in Appendix C "Risk Assessment" and discussed in Section 2.4 "Development of Preliminary Remediation Goals." Results from the current risk evaluation were then used as a baseline to assess the relative risk reduction afforded by the No Action alternative, by active remediation of the Area of Focus, or by active remediation of the Primary Erosional Zone and Primary Inventory Zone. Table 2-11 presents a summary of these results.

Table 2-11: Summary of Baseline and Future Cancer Risk and Non-cancer Health Hazards and the Relative Reductions in Risk/Hazard after 30 Years

<table>
<tr><th rowspan="2">Fish Consumption</th><th rowspan="2">Time Period[d]</th><th rowspan="2">Adult + Child Combined Risk</th><th rowspan="2">Adult Hazard</th><th rowspan="2">Child Hazard</th><th colspan="3">Relative Reduction[c]</th></tr>
<tr><th>Combined Risk</th><th>Adult Hazard</th><th>Child Hazard</th></tr>
<tr><td rowspan="3">No Action Alternative[a]</td><td>2018</td><td>$6x10^{-3}$</td><td>24</td><td>37</td><td>42%</td><td>63%</td><td>63%</td></tr>
<tr><td>2019-2025</td><td rowspan="2">$4x10^{-3}$</td><td>20</td><td>31</td><td rowspan="2">64%</td><td>69%</td><td>69%</td></tr>
<tr><td>2042-2048</td><td>7</td><td>ND[f]</td><td>89%</td><td>ND[f]</td></tr>
<tr><td rowspan="3">Active Remediation of Primary Erosional Zone/Primary Inventory Zone</td><td>2018</td><td>$4x10^{-3}$</td><td>21</td><td>33</td><td>58%</td><td>67%</td><td>67%</td></tr>
<tr><td>2019-2025</td><td rowspan="2">$2x10^{-3}$</td><td>18</td><td>29</td><td rowspan="2">75%</td><td>72%</td><td>71%</td></tr>
<tr><td>2042-2048</td><td>6</td><td>ND[f]</td><td>91%</td><td>ND[f]</td></tr>
<tr><td rowspan="3">Active Remediation of Area of Focus</td><td>2018</td><td>$9x10^{-4}$</td><td>16</td><td>25</td><td>91%</td><td>75%</td><td>75%</td></tr>
<tr><td>2019-2025</td><td rowspan="2">$5x10^{-4}$</td><td>14</td><td>22</td><td rowspan="2">95%</td><td>79%</td><td>78%</td></tr>
<tr><td>2042-2048</td><td>5</td><td>ND[f]</td><td>92%</td><td>ND[f]</td></tr>
<tr><td colspan="2">Baseline[e]</td><td>$1x10^{-2}$</td><td>64</td><td>99</td><td colspan="3"></td></tr>
</table>

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Table 2-11continued: Summary of Baseline and Future Cancer Risk and Non-cancer Health Hazards and the Relative Reductions in Risk/Hazard after 30 Years (continued)

Crab Consumption	Time Period[d]	Adult + Child Combined Risk	Adult Hazard	Child Hazard	Relative Reduction[c] Combined Risk	Relative Reduction[c] Adult Hazard	Relative Reduction[c] Child Hazard
No Action Alternative	2018	$4x10^{-3}$	19	31	78%	77%	78%
	2019-2025	$3x10^{-3}$	16	27	87%	81%	81%
	2042-2048		5	ND[f]		94%	ND[f]
Active Remediation of Primary Erosional Zone/Primary Inventory Zone	2018	$3x10^{-3}$	17	28	84%	80%	80%
	2019-2025	$2x10^{-3}$	14	24	91%	83%	83%
	2042-2048		5	ND[f]		94%	ND[f]
Active Remediation of Area of Focus	2018	$8x10^{-4}$	13	21	96%	85%	85%
	2019-2025	$4x10^{-4}$	11	19	98%	87%	87%
	2042-2048		4	ND[f]		95%	ND[f]
Baseline[e]		$2x10^{-2}$	86	140			

a: Detailed discussion of the remedial alternatives is provided in Section 2.5.1 "Target Area Identification Analyses."
b: The approach used to estimate risk/hazard for human receptors is provided in Appendix C "Risk Assessment."
c: Baseline conditions compared to estimated condition 30 years following implementation.
d: The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 are used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e.*, 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.
e. The current scenario is assumed to represent the risks in 2007, before remediation is initiated and prior to accounting for natural degradation (*e.g.*, monitored natural recovery). Current risk represents the RME as described in Section 5.3.1 and provided in Attachment 4 of Appendix C, Tables 4-16 and 4-18.
f. ND – not determined. Only the adult receptor is evaluated for non-cancer health hazards for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult, rather than the child, may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

The results of the baseline HHRA indicate that current cancer risks and non-cancer health hazards exceed the NCP criteria for consumption of fish and crab and support the need for remedial action. With respect to the evaluation of future remedial scenarios, the total risk/hazard levels are still above the NCP criteria for the No Action alternative and active remediation in the Primary Erosional Zone and Primary Inventory Zone. However, the total cancer risk estimated for active remediation of the Area of Focus is at the upper end of the NCP risk range 30 years following remediation (*i.e.*, by 2048). In addition, the active remediation alternatives rely in monitored natural recovery and institutional controls to achieve the NCP risk range in future years. Also, separate source control actions above Dundee Dam, when implemented, will shorten the time frame within which the active remediation alternatives achieve the risk range. Note also that active remediation of the Area of Focus resulted in the greatest reduction in risk/hazard. The HHRA was conducted consistent with USEPA guidance (RAGS Part D, USEPA 2001a), guidelines, and policy, and the uncertainties associated with the risk/hazard estimates are discussed in the HHRA (Appendix C "Risk Assessment").

2.6.2 Ecological Risk Assessment Summary

The ERA conducted to support the FFS evaluated direct contact exposures by sediment-associated receptors to contaminated sediment. In addition, the bioaccumulation hazards to aquatic organisms that forage in the Lower Passaic River and the wildlife that consume them were evaluated. Receptors of interest include sediment-dwelling and epibenthic macroinvertebrates, pelagic and demersal fish, and piscivorous wildlife (mink and great blue heron).

A chemical screening process was used to select nine COPEC for consideration, including copper, lead, mercury, LPAH, HPAH, dieldrin, Total DDx, Total PCB, and TCDD TEQ, including contributions from PCDD/F and PCB congeners. Screening level exposure assumptions were used to model dietary exposures and protective toxicity values [*e.g.*, NOAA effects range-low (ER-L) concentrations, low end, no observed-adverse-effects levels (NOAEL), lowest observed-adverse-effects levels (LOAEL), critical body residues (CBR), and ingestion toxicity data] to ensure that potential ecological hazards were conservatively estimated in the assessment.

The process of evaluating remedial alternatives to address ecological concerns employed the same risk assessment methodology, including potential exposure scenarios and toxicological data used in the assessment of current conditions (presented in Section 6.0 of Appendix C "Risk Assessment"). Results from the assessment of current conditions were then used to assess the relative risk reduction afforded by each of the remedial scenarios evaluated. In addition, the relative risk reduction among the three scenarios was examined. Incremental hazards (*i.e.*, those above background) were not calculated because necessary analytical data from above Dundee Dam were not available at the time of report preparation.

Table 2-12 presents a summary of the geometric mean of the NOAEL and LOAEL HI calculated for the evaluated receptors for current conditions and for each of the three selected remedial scenarios. The geometric mean is used here to present the risk based on a single effect level. These findings strongly support a conclusion that ecological receptors that reside in the river currently are being adversely impacted as a result of exposure to COPECs associated with the river sediment and biological tissue. With respect to the evaluation of future remedial scenarios, the Area of Focus scenario resulted in the greatest reduction in ecological hazards and ecological improvements are predicted to occur in a substantially shorter period of time. None of the remedial scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, by Year 2048, it is anticipated that wildlife receptors would have a hazard reduction of 78 to 98 percent for remediation of the Area of Focus. Again, separate source control actions above Dundee Dam, when implemented, will accelerate the time frame within which the active remedial alternatives for the Area of Focus will reach the condition of no significant risk of harm for the ecological receptors. The ERA also determined that there were significant uncertainties with the benchmarks used to screen sediment and biological tissue concentrations and that the potential hazards associated with these endpoints were conservatively evaluated. Although a Baseline Ecological Risk Assessment has not yet been completed, it is anticipated that the potential hazards identified in this analysis will represent an upper bound to more realistically-derived values.

Table 2-12: Summary of Ecological Hazards Associated with Current Conditions and Various Remedial Scenarios

Receptor/ Endpoint	Remedial Scenario[a]	Baseline Hazard[b]	Estimated Future Hazard[b]		Hazard Reduction[c]
			2018	2048	
Macroinvertebrates/sediment benchmarks					
	Monitored Natural Recovery	1,898	1,577	1,259	34%
	Primary Erosional Zone/Primary Inventory Zone		1,388	1,160	39%
	Area of Focus		383	326	83%
Macroinvertebrates/CBRs[d]					
	Monitored Natural Recovery	1,665	771	261	84%
	Primary Erosional Zone/Primary Inventory Zone		612	220	87%
	Area of Focus		199	78	95%
Fish (American eel/white perch)/CBRs					
	Monitored Natural Recovery	6,858	2,637	1,054	85%
	Primary Erosional Zone/Primary Inventory Zone		2,373	955	86%
	Area of Focus		1,215	497	93%
Fish (mummichog)/CBRs					
	Monitored Natural Recovery	694	703	302	56%
	Primary Erosional Zone/Primary Inventory Zone		646	279	60%
	Area of Focus		352	155	78%
Mammal (mink)/ingestion dose modeling					
	Monitored Natural Recovery	339	166	52	85%
	Primary Erosional Zone/Primary Inventory Zone		121	34	90%
	Area of Focus		22	6	98%
Bird (heron)/ingestion dose modeling					
	Monitored Natural Recovery	49	17	5	89%
	Primary Erosional Zone/Primary Inventory Zone		14	4	92%
	Area of Focus		6	2	96%

a: A detailed discussion of the remedial alternatives is provided in Section 2.5 "Identification of Potential Target Areas for Remediation."
b: The approach used to estimate ecological hazards is provided in Appendix C "Risk Assessment". Where bounding estimates of the hazards were derived, the geometric mean of the upper and lower bounds are provided above.
c: Compared to baseline conditions after 30 years.
d: Critical Body Residues (CBR) are threshold tissue concentrations above which adverse effects have been reported in the literature.

2.6.3 Comparison of Reduction of COPC and COPEC Concentrations

Given the natural processes that are occurring in the river, the concentrations of most COPCs and COPECs will decline over time regardless of the method chosen for remediation. However, based on the Empirical Mass Balance Model and concentration projections discussed above, active remediation has a significant effect on how quickly the recovery will occur as compared to MNR alone (Appendix D "Empirical Mass

Balance Model"). Any chosen remediation goal will be achieved sooner by active remediation than by MNR except for chemicals that have continuing sources external to the river. Table 2-13 gives the reduction of time in years for each COPC and COPEC for the Area of Focus alternative as compared to MNR.

Table 2-13: Time Difference between MNR Scenario and Area of Focus Scenario

Analyte	Time Difference (Years)
Mercury	10
Lead	5
Copper	5
Total Chlordane	-
DDE	15
DDD	15
DDT	15
Total DDT	15
Dieldrin	-
2,3,7,8-TCDD	40
PCDD/F TEQ	40
Total PCB	10
PCB TEQ Mammal	10
PCB TEQ Bird	10
PCB TEQ Fish	10
Total TEQ Mammal	40
Total TEQ Bird	25
Total TEQ Fish	40
LMW PAH	-
HMW PAH	-

The symbol (-) represents no time difference.

The concentrations of COPCs and COPECs in sediment selected as the PRG are based on background concentrations found in recently deposited sediment above Dundee Dam (see section 2.4.4 "PRG Selection" and Table 2-7). Given the projected declines in COPC and COPEC concentrations due to the different remedial scenarios, an assessment can be made of the PRG selected for each compound:

Copper: Copper is not a COPC for human health so human health thresholds were not developed for comparison. The selected level may not immediately be protective of benthos or wildlife although remediating the Area of Focus is anticipated to achieve protective levels for benthos sometime after 2048 due to natural recovery processes.

Lead: Lead is also not a COPC for human health so human health thresholds were not developed for comparison. The selected level may not immediately be protective of benthos or wildlife although remediating the Area of Focus is anticipated to achieve protective levels for benthos sometime after 2048 due to natural recovery processes.

Mercury: Natural recovery alone would result in mercury concentrations below background by approximately 2021 and non-cancer hazards below HI=1 for 40 fish-meals per year before 2018. Remediating the Primary Erosional Zone or the Area of Focus would result in concentrations immediately achieving background levels or lower. Cancer thresholds have not been developed for comparison. The selected level may not be protective of benthos or wildlife, however remediating the Area of Focus may be protective of benthos sometime after 2048 due to natural recovery processes, while protection of wildlife would take somewhat longer.

LMW PAH: LMW PAH is not a COPC for human health or a COPEC for wildlife so no thresholds were developed for comparison. A level that protects benthos is not likely achieved by any scenario; however ecological exposures in remediated areas would be consistent with background. The selected level is met by 2018 regardless of action.

HMW PAH: HMW PAH is not a COPC for human health or a COPEC for wildlife so no thresholds were developed for comparison. A level that protects benthos is not likely achieved by any scenario; however ecological exposures in remediated areas would be consistent with background. The selected level is met by 2018 regardless of action.

Total PCB: The total PCB level protects human health at 6 meals per year (10^{-4} cancer risk) or 1 meal per year (10^{-5} cancer risk and non-cancer HI), but may not protect benthos or wildlife. The benthos and wildlife exposures would be consistent with background. The selected level is met by 2018 regardless of action.

Total DDx: Total DDx is not a COPC for human health so thresholds were not developed for comparison. The chosen level is not protective of benthos or wildlife although exposures would be consistent with background conditions. The selected level is met by 2018 regardless of action.

Total Chlordane: The chosen Total Chlordane level protects human health at 40 meals per year (10^{-4} cancer risk) or 12 meals per year (non-cancer HI). Total Chlordane is not a COPEC for benthos or wildlife evaluation. The selected level is met by 2018 regardless of action.

Dieldrin: Dieldrin is not a COPC for human health so no thresholds were developed for comparison. The selected level is protective of wildlife, but not benthos. The selected level is met by 2018 regardless of action.

PCDD/F: The selected PCDD/F level protects human health between 2 and 6 meals per year at a 10^{-6} cancer risk, or at 40 meals per year for a 10^{-5} cancer risk. Non-cancer thresholds were not developed for comparison. The selected level also protects benthos and wildlife. The selected level is likely to be met sometime after 2048 if the Area of Focus is remediated. Concentrations in the Area of Focus are projected to drop within the human health risk range (10^{-4} for 40 meals per year) upon completion of active remediation of the Area of Focus by 2018. Thresholds for benthos and wildlife will likely be met sometime after 2048 (and before achieving background levels) assuming remediation of the Area of Focus. No Action is projected to achieve any threshold 40 years later than active remediation of Area of Focus.

2.7 SELECTION OF TARGET AREA FOR REMEDIATION

The COPC and COPEC concentrations known to exist in the surface sediments of the Area of Focus are clearly greater than the risk-based PRGs and the background concentrations. For this reason a remedial strategy that can reduce the concentrations to at least the level of background is necessary to begin to achieve the RAOs. The above analyses considered the No Action alternative, active remediation of the Primary Erosion Zone and the Primary Inventory Zone, and active remediation of the Area of Focus. The evaluations of risk, development of PRGs, and estimation of future concentrations were used to evaluate the benefit of remediating each of the three target areas. Based on the estimated risk reduction described in Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas," neither the No Action alternative nor the active remediation of the Primary Erosional Zone and the Primary Inventory Zone will achieve residual risks below the acceptable USEPA threshold within reasonable time frames. In addition, sediment concentrations exceeding PRGs have been identified throughout the Area of Focus, and active remediation of the Primary Erosion Zone and the Primary Inventory Zone does not address these continuing contaminant sources. Active remediation of the Area of Focus reduces the COPC and COPEC concentrations in the surface sediments to within the background concentrations that are currently introduced to the Lower Passaic River from the Upper Passaic River, reduces the human health risk by 95 to 98 percent, and reduces the ecological hazard by 78 to 98 percent (refer to Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas"), which meets the RAO. Based on prediction of future surface concentrations generated using the Empirical Mass Balance Model (Appendix D), active remediation of the Area of Focus followed by MNR achieves any threshold for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by MNR alone. The reduction of other COPCs and COPECs is also accelerated by the remediation of the Area of Focus. For these reasons, the Area of Focus is the preferred target area. Therefore, all active alternatives that are presented in Section 4.0 "Development of Remedial Action Alternatives" are developed to remediate the fine-grained sediments of the lower 8 miles in their entirety.

3.0 IDENTIFICATION AND SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGY CLASSES, AND PROCESS OPTIONS

General response actions are categories of actions that may be implemented to achieve the Study's RAOs. This section identifies and screens general response actions, remedial technology classes, and process options that are potentially applicable to a Source Control Early Action to remediate contaminated sediment in the Area of Focus. The technology selection and screening processes were conducted in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988).

Various databases, technical reports, and publications (refer to Section 3.2 "Sources and Methods for Identification of Potentially Applicable Technologies") were used to conduct a search to identify potentially applicable technologies based on the general response actions identified below. The selected technology classes were then expanded into lists of potentially applicable process options.

Ancillary technologies, such as sediment disposal options, sediment dewatering, wastewater treatment, sediment transportation options and site restoration options are discussed in Section 3.4 "Ancillary Technologies".

It is important to note that screening processes were conducted solely for the purposes of an early action within the Area of Focus. Technologies and process options were identified, evaluated, and screened (resulting in retention or elimination) based on their applicability for this purpose. The development of the feasibility study for the overall 17-mile comprehensive Study may identify, evaluate, and screen a wider set of technologies.

3.1 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

The first step in the development and screening of alternatives is to identify general response actions that may be taken to satisfy the RAOs for the FFS. The general response actions identified are as follows:

- No action.
- Institutional controls.
- MNR.
- Containment.
- *In situ* treatment.
- Sediment removal.
- *Ex situ* treatment.
- Beneficial use of dredged sediment.
- Disposal of dredged sediment.

A brief description of each of the general response actions is provided below.

3.1.1 No Action

Consideration of a No Action response is required by the NCP. The No Action response serves as a baseline against which the performance of other remedial alternatives may be compared. Under the No Action response, contaminated river sediment will be left in place without treatment or containment. No additional institutional controls would be implemented as part of the No Action alternative; however, it is assumed that existing institutional controls would be continued.

3.1.2 Institutional Controls

Institutional controls are legal or administrative measures designed to prevent or reduce human exposure to on-site hazardous substances. Fish consumption advisories and dredging restrictions are examples of relevant institutional controls for the Lower Passaic River. Institutional controls are typically implemented in conjunction with other remedy components.

3.1.3 Monitored Natural Recovery

Natural recovery refers to the decline in contaminant concentrations in impacted media over time via natural processes that contain, destroy, or reduce bioavailability or toxicity of contaminants. These naturally occurring mechanisms include physical phenomena (*e.g.*, burial and sedimentation), biological processes (*e.g.*, biodegradation), and chemical processes (*e.g.*, sorption and oxidation). MNR includes monitoring, and may include modeling, to assess the whether these natural processes are occurring and at what rate they may be reducing contaminant concentrations, but does not include active remedial measures. MNR may be an appropriate response action if natural recovery processes can achieve site-specific RAOs in a time frame that is reasonable compared to other active remedial measures. In addition, MNR may be used as one component of a total remedy, either in conjunction with active remediation or as a follow-up measure to continue to reduce contaminant concentrations.

3.1.4 Containment

Containment entails the physical isolation or immobilization of contaminated sediment, for example, by an engineered cap. Assuming effective cap design and construction, containment results in the isolation of contaminated sediment, thereby limiting potential exposure to, and mobility and bioavailability of, contaminants bound to the sediment.

3.1.5 In Situ Treatment

In situ treatment technologies may be used to reduce contaminant concentrations without removal or containment of the contaminated sediments. Some *in situ* processes, such as stabilization and solidification, may reduce contaminant mobility or bioavailability.

3.1.6 Sediment Removal

Sediment removal may be accomplished by dredging or excavation of contaminated sediment for subsequent treatment or disposal. This response results in the removal of contaminant mass from the river bed.

3.1.7 Ex Situ Treatment

Ex situ treatment involves the application of technologies to transform, destroy, or immobilize contaminants following removal of contaminated sediments. Numerous *ex situ* treatment options are available. After *ex situ* treatment, treated dredged sediment could either be applied to a beneficial use or disposed on land or in water (if it meets disposal criteria). Both of these general response actions are discussed below.

3.1.8 Beneficial Use of Dredged Sediments

Following removal and, if necessary, *ex situ* treatment, dredged material could potentially be applied for a beneficial use. Sediment that meets applicable criteria for contaminant concentrations and structural properties could serve a beneficial purpose such as structural fill or lower permeability cover or cap for a brownfield or landfill without pre-treatment. In some instances, *ex situ* treatment, such as *ex situ* immobilization, is required prior to application of dredged sediment as fill or cover material. In addition, certain *ex situ* treatment processes result in the formation of an end product that can be beneficially used (*e.g.*, formation of glass following vitrification, or formation of cement aggregate following certain thermo-chemical processes).

3.1.9 Disposal of Dredged Sediments

The definition of 'disposal' used in the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005) has been adopted for use here. Namely, 'disposal' refers to the placement of dredged or excavated material into a permanent or temporary structure, site, or facility. Depending on the disposal location, the dredged or excavated material may undergo limited or extensive prior treatment.

3.2 SOURCES AND METHODS FOR THE IDENTIFICATION OF POTENTIALLY APPLICABLE TECHNOLOGIES

Several databases, guidance documents, and feasibility studies for similar sediment remediation projects were used to identify potentially applicable remedial technologies. The following sources are of particular note:

- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005).
- Federal Remediation Technologies Roundtable (FRTR) website (www.frtr.gov/matrix2/top_page.html).
- USEPA Hazardous Waste Clean-up Information website (www.clu-in.org/).
- Assessment and Remediation of Contaminated Sediments (ARCS) Program, *Remediation Guidance Document* (USEPA, 1994).
- Equipment and Placement Techniques for Subaqueous Capping (Bailey and Palermo, 2005).
- Final Feasibility Study, Lower Fox River and Green Bay, Wisconsin (RETEC Group, Inc., 2002).
- Hudson River PCBs Reassessment RI/FS Phase 3 Report: Feasibility Study (TAMS Consultants, Inc., 2000).
- Dredging Technology Review Report (TAMS, an Earth Tech Company and Malcolm Pirnie, Inc., 2004).
- NJDOT Office of Maritime Resources (NJDOT-OMR), Sediment Decontamination Technology Demonstration Program Website (www.state.nj.us/transportation/works/maritime/dresediment.shtm).

3.3 TECHNOLOGY CLASS IDENTIFICATION AND SCREENING

Technology classes presented in this section are grouped by general response action type as identified in Section 3.1 "Identification of General Response Actions." Tables 3-1a through 3-1i describe the technology classes that encompass the means for achieving these general response actions. For example, removal is a general response action that may achieve RAOs using the technology class of dredging. Specific process options were identified within each technology class. For instance, dredging, which is a technology class, includes such process options as hydraulic dredging, mechanical dredging, and specialty dredging. Process options applicable to the Area of Focus are selected based on an understanding of the characteristics of the contaminated media.

Tables 3-1a through 3-1i also subject the identified process options to a screening based on the three criteria of implementability, effectiveness, and relative cost. These criteria are described below.

- Implementability refers to the technical and administrative feasibility of applying a particular process option. To determine the implementability of a process option in the Area of Focus, such factors as obtaining permits for on-site and off-site treatment and disposal options; the availability of treatment, storage, and disposal facilities; and the availability of necessary equipment and skilled workers to accomplish the work are considered.
- Effectiveness determines the efficacy of a process option, and involves the following considerations:
  - The ability of the process option to reduce the toxicity, mobility, and/or volume of contaminant mass through treatment.
  - The degree to which it minimizes residual risks and affords long-term protection.
  - How quickly it achieves protection.
  - The capacity of the process to handle the areas or volumes of contaminated sediment to be remediated.
  - The degree to which it minimizes short-term impacts to human health and the environment during the construction and implementation phase.
  - The reliability of the process with respect to the contaminants and conditions in the Area of Focus.
- Relative costs for capital as well as operations and maintenance (O&M) were estimated for each process option for screening purposes. Cost discriminators used for screening are defined in terms of very high, high, moderate, and low, based on engineering judgment. For the purposes of this discussion, costs of less than $100/ton of sediments were considered low, $100 to $500/ton were considered moderate, costs between $500 and $1,000/ton were considered high, and costs over $1,000/ton were considered very high. In accordance with the RI/FS guidance (USEPA, 1988), cost plays a limited role in this preliminary screening of technology classes and process

options; that is, cost considerations will not be weighed as heavily as the implementability and effectiveness of process options during screening.

Section 3.3.1 "General Response Action: No Action" through Section 3.3.8 "General Response Action: Beneficial Use of Dredged Sediments" provide brief descriptions of the general response actions, technology classes, and process options, and also summarize the results of the screening process. For additional information, refer to Tables 3-1a through 3-1i.

3.3.1 General Response Action: No Action

Under the No Action response, no activities involving removal, containment, treatment, engineering controls, or new institutional controls are implemented; however, a No Action response may include maintenance of existing institutional controls and/or some type of environmental monitoring to verify that unacceptable exposures to hazardous substances do not occur in the future (USEPA, 1988). While sediments in the Area of Focus pose unacceptable human health and ecological risks (Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas"), the NCP requires that No Action be considered as a potential remedial action in a Feasibility Study. It is assumed that the No Action and MNR responses would be equivalent in terms of predicted future concentrations and risk reduction (Appendix D "Empirical Mass Balance Model"). The No Action response will be retained for further evaluation.

3.3.2 General Response Action: Institutional Controls

Institutional controls are potentially applicable and technically implementable as shown by fish consumption advisories for PCDD/F and PCB currently in place for the Lower Passaic River. The action is potentially effective for reducing risk to human health by limiting exposure, but not effective in reducing mobility, toxicity, or volume of contaminants. Institutional controls such as fish consumption advisories, limitations on recreational use, restrictions on private sediment disturbance activities, and dredging moratoriums could be implemented as components of alternatives comprising active remedial measures; therefore, the institutional controls response is retained for further evaluation.

3.3.3 General Response Action: Monitored Natural Recovery

The *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005) identifies MNR as a potential remedial alternative for managing contaminated sediments. This guidance document defines MNR as a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments.

Changes in surface sediment concentrations over time as determined from dated cores indicate that natural recovery is occurring to some extent in the Area of Focus; however, the process is occurring at a rate that is incompatible with its application as an early action (refer to Appendix D "Empirical Mass Balance Model"). MNR processes are not effective in reducing mobility, toxicity, or volume of contaminants within a reasonable time period. MNR, while easily implementable, may not be effective as the sole component of an early action.

MNR could, however be implemented as a component of alternatives comprising other active remedial measures. Therefore, MNR has been retained for further consideration as a component that would follow active remedial measures.

3.3.4 General Response Action: Containment

Sediment containment is usually achieved via the placement of a subaqueous covering or a cap of clean material over contaminated material that remains in place. Containment generally can reduce exposure to contaminants more quickly than sediment removal, because there should be very little contaminant residual on the cap surface (USEPA, 2005). It also requires less infrastructure than sediment removal, in terms of materials handling, dewatering and treatment (USEPA, 2005). In addition, the need for transport and disposal of contaminated sediment, which is more costly when *ex situ* treatment is required, is negligible for containment compared to removal.

3.3.4.1 Technology Class: Capping

Engineered Caps. Engineered caps involve the placement of sand or other suitable cover material over the top of contaminated sediments. Engineered caps are implementable and many full-scale applications have been documented (refer to SedWebSM website, www.sediments.org/capsummary.pdf). They are effective in reducing mobility of contaminants by isolating impacted sediments from the water column, but will not affect toxicity or volume of contaminants. Their effectiveness may be limited because they decrease water depth, which may constrain future navigation uses of the river and potentially increase flooding. Engineered caps have been retained for further evaluation.

Engineered caps may use armor material to add physical stability in erosive settings. The primary capping material (*e.g.*, sand) is typically covered with stone or another armoring material. The armor would be designed to be effective in reducing the erosion of the engineered sand cap; however, armoring along the channel bed increases bed friction and, consequently, may increase water depths during floods. Armoring may also pose a risk of damage to ship hulls in navigable reaches. In addition, the design of an armor layer should take habitat considerations into account (*e.g.*, appropriateness of angular versus rounded stone). Nevertheless, since armored engineered caps are technically implementable and effective, they have been retained for further evaluation.

Active Caps. Active caps incorporate materials such as activated carbon, iron filings, apatite, or other agents into the capping material to enhance adsorption or in-situ chemical reaction. Active caps eventually lose their sorptive or chemically reactive treatment capabilities and are typically more difficult to construct than engineered sand caps. Active capping is an emerging technology that has shown much promise in bench-scale, and in limited example pilot-scale applications. It has yet to be applied routinely at full scale, and therefore would not be suitable for near term action.

Geotextile Caps. Porous geotextile cap layers do not achieve sediment isolation, but serve to reduce the potential for mixing and displacement of the underlying sediment with the cap material. Geotextiles allow the sediments to consolidate and gain strength under the load of additional cap material. While application of this material over a large area may be exceptionally challenging for construction, geotextile caps may be considered during the design phase, perhaps to allow for engineered capping of sediments in selected areas that do not have adequate strength to support a cap. Geotextiles are therefore retained.

Clay Caps. Clay aggregate materials (*e.g.*, AquaBlok™) consist of a gravel/rock core covered by a layer of clay mixed with polymers that expand in water, decreasing the material's permeability. Since the use of clay caps over large areas has not been documented, the effectiveness is unknown. Therefore, clay caps have not been retained for further evaluation.

3.3.4.2 Technology Class: Structural Containment

Structural containment systems, such as silt traps, create conditions within hydraulic systems that restrict or reduce flow to such an extent that suspended sediment is removed from suspension. While structural containment systems are likely to be technically implementable, a preliminary analysis (Appendix E "Engineering Memoranda: Silt Trap Evaluation") indicates that a silt trap would not be effective due to the hydrodynamic and sediment transport conditions present in the Area of Focus. Hence, structural containment will not be retained for further evaluation.

3.3.5 General Response Action: In Situ Treatment

In situ treatment of sediments refers to chemical, physical, or biological techniques for reducing contaminant concentrations and/or contaminant mobility while leaving the contaminated sediment in place.

3.3.5.1 Technology Class: Immobilization

Immobilization refers to treatment processes such as solidification/stabilization and encapsulation that physically or chemically reduce the mobility of hazardous constituents in a contaminated material. *In situ* immobilization methods typically involve amending sediments in place with agents such as cement, quicklime, grout, or pozzolanic materials, as well as other reagents. These agents are mixed through the zone of contamination using conventional excavation equipment or specially designed injection apparatus such as mixing blades attached to vertical augers.

Contaminant Fixation. Immobilization with the goal of contaminant fixation would seek to physically and/or chemically bind contaminant molecules. Full-scale applications of *in situ* solidification/stabilization of sediments are limited and have primarily focused on the improvement of the geotechnical properties of sediment for construction projects, as opposed to stabilization with the goal of contaminant mass remediation. The two most applicable case studies that were found during a literature search are the Minamata Bay project in Japan, and a pilot study sponsored by NJDOT-OMR in the New York-New Jersey Harbor. These case studies have been summarized in a memorandum included in Appendix E "Engineering Memoranda." Neither of these case studies provided sufficient data to evaluate the effectiveness of immobilization for the purpose of contaminant fixation. Therefore, this process option will not be retained for further evaluation.

Erosion Control. Immobilization of surficial sediments for erosion control is potentially implementable and effective in reducing mobility of contaminated sediments. The potential effectiveness cannot be evaluated due to the lack of available precedent for this process. Therefore, this process option will not be retained for further evaluation.

Geotechnical Improvements. Use of immobilization for improvement in sediment geotechnical properties is fairly common (typically referred to as deep soil mixing). In addition, improvement of geotechnical properties of sediments in an area to be dredged may render the sediment more suitable for accurate dredging, and may reduce sediment resuspension, precluding the need to use containment measures. Immobilization applied after dredging could result in a more consolidated sediment bed, which would reduce sediment transport. This option will be retained as a potential ancillary technology to other process options.

3.3.5.2 Technology Class: Physical Extractive Treatment

Surfactant-enhanced extraction and solvent extraction were considered as *in situ* treatments. These treatments involve the use of an organic solvent or surfactant as an agent to separate primarily organic contaminants from sediment. For *in situ* extraction, the solvent or surfactant would be injected into the contaminated sediment and then recovered. Treatment or destruction of the contaminant-bearing surfactant or solvent would be accomplished *ex situ*. There are no known sediment applications of process options in this technology class to demonstrate effectiveness. Therefore, physical extractive process options have been eliminated from further evaluation.

3.3.5.3 Technology Class: Biological Treatment

Biological treatment is a technique in which the physical, chemical, and biological conditions of a contaminated medium are manipulated to accelerate the natural biodegradation and mineralization processes. Persistent contaminants, such as those found in Lower Passaic River sediments (*e.g.*, PCB, PCDD/F), are frequently resistant to microbial degradation for the following reasons (Renholds, 1998):

- Poor contaminant bioavailability to microorganisms.
- Contaminant toxicity to the microorganisms.
- Preferential feeding of microorganisms on other substrates.
- Microorganisms' inability to use a compound as a source of carbon and energy.
- Unfavorable environmental conditions in sediments for propagation of appropriate microorganisms.

Since many of the Lower Passaic River contaminants are either not biodegradable (particularly heavy metals) or are very persistent in the environment (*e.g.*, PCDD/F, PCB, pesticides), it is not considered feasible to implement biological treatment. Therefore, *in situ* biological treatment will not be considered for further evaluation.

3.3.5.4 Technology Class: Chemical Treatment

In situ chemical treatment would involve the injection of chemical reagents, typically chemical oxidants or reductants, to chemically react with contaminants to form less toxic by-products. There are no known sediment applications of these process options to demonstrate effectiveness and implementability. Therefore, *in situ* chemical treatment options will not be retained for further evaluation.

3.3.6 General Response Action: Sediment Removal

Sediment removal is employed in those cases where contaminated sediments are to be withdrawn for *ex situ* treatment (refer to Section 3.3.7 "General Response Action: *Ex Situ* Treatment") and/or disposal or beneficial reuse (refer to Sections 3.3.8 "General Response Action: Beneficial Use of Dredged Sediment" and 3.3.9 "General Response Action: Disposal of Dredged Sediments"). Sediment removal, if it achieves cleanup levels for the site, may result in the least uncertainty about long-term effectiveness, since it can minimize the potential for future exposure and transport of contaminants (USEPA, 2005).

3.3.6.1 Technology Class: Excavation

Excavation of contaminated sediment involves pumping or diverting water from the area to be excavated, managing continuing inflow, and excavating contaminated sediment using conventional land-based excavators (such as backhoes). Excavation is considered both implementable and effective for mass remediation in the Area of Focus. Excavation technologies have been retained for further evaluation.

3.3.6.2 Technology Class: Dredging

Dredging involves mechanically grabbing, raking, cutting, or hydraulically scouring the bottom of a waterway to dislodge sediment. Once dislodged, the sediment may be removed either mechanically with dredge buckets, or hydraulically by pumping.

Mechanical Dredging. Mechanical dredges remove sediments from the bottom of a waterway using dredge buckets. The mechanical dredges most commonly used in the

United States for environmental dredging are the clamshell, enclosed bucket, and articulated mechanical dredges (USEPA, 2005). The Dredging and Decontamination Pilot Study was conducted in the Lower Passaic River over the period of one week in December 2005 (Baron *et al.*, 2005). The pilot study provided data related to dredging accuracy, working time, productivity (Thompson *et al.*, 2006), and resuspension (Mahmutoglu *et al.*, 2007) for a mechanical clamshell dredge bucket. Mechanical dredging has been retained for further evaluation.

Hydraulic Dredging. Hydraulic dredges remove and transport dredged materials as a pumped sediment-water slurry. Implementation of this process option would require that significant infrastructure be constructed to convey, process, and dewater dredged slurry, and this infrastructure would likely require significant acreage near the site of dredging. In addition, the presence of debris could hinder the productivity of hydraulic dredges. Despite these challenges, given the soft, unconsolidated nature of the Area of Focus sediment, hydraulic dredging is a potentially effective means of sediment removal. Hydraulic dredging has been retained for further evaluation.

Specialty Dredges. Specialty dredges have been designed to address project-specific issues, such as accessibility and resuspension. Although specialty dredging techniques exist that may be technically implementable, conventional dredges are generally more effective with regard to productivity and working conditions, and advances in environmental dredging have effected improvements in precision sufficient for most situations. Specialty dredges will not be evaluated further in this FFS, but may be considered for managing specific situations that may become evident during a design phase.

3.3.7 General Response Action: Ex Situ Treatment

Ex situ treatment of sediments refers to chemical, physical, or biological techniques for reducing contaminant concentrations and/or contaminant mobility in dredged material.

3.3.7.1 Technology Class: Immobilization

Immobilization refers to treatment processes that physically or chemically reduce the mobility of contaminant constituents in dredged material. *Ex situ* immobilization methods involve mixing setting agents such as cement, quicklime, grout, pozzolanic materials, and/or reagents with sediments in a treatment unit. Sediments generally require some pre-processing, such as screening of oversized material, prior to solidification/stabilization. The effectiveness of solidification/stabilization technologies is variable depending on the characteristics of the contaminated sediment and the particular additives used. Solidification/stabilization of sediment is commonly required prior to its use in a beneficial application, such as for construction fill. A knowledge base for this technology exists within the Port of New York and New Jersey region using navigationally dredged material; project examples include the Orion of Elizabeth New Jersey (OENJ) shopping mall construction, OENJ Bayonne golf course, and EnCap Gold Holdings, LLC Golf Holdings golf course in Lyndhurst, New Jersey.

Since ex-situ immobilization may effectively fix or bind contaminants in dredged material, and because such immobilized dredged material has potential beneficial uses (including sanitary landfill cover, construction fill, and mined land restoration), this technology will be retained for further consideration.

3.3.7.2 Technology Class: Physical/Chemical Extractive Treatment

Solvent Extraction. Solvent extraction involves the use of an organic solvent as an agent to separate primarily organic contaminants from dredged material. Using such a process alone would likely be insufficient to treat the dredged material given the variety of contaminants. Therefore, solvent extraction will not be further evaluated as a process option, but "Surfactant Enhanced Recovery" may be considered as a step in a treatment train for sediment washing (see below).

Sediment Washing. Sediment washing is a water-based volume reduction process similar to the soil washing techniques used in the mining industry. During this process contaminants are extracted and concentrated into a small residual portion of the original volume using physical and chemical means (USEPA, 2005). Since this process was shown to be implementable and potentially effective by BioGenesis™ Enterprises, Inc. for dredged material from Newark Bay and the Lower Passaic River, sediment washing is retained for further evaluation. Refer to Appendix H "Dredged Material Management Assessments" for more information.

3.3.7.3 Technology Class: Biological Treatment

Biological treatment is a technique in which the physical, chemical, and biological conditions of a contaminated medium are manipulated to accelerate the natural biodegradation and mineralization processes. Since many of the contaminants present in the Area of Focus are either not biodegradable (*e.g.*, heavy metals) or are resistant to biological degradation (*e.g.*, PCDD/F, Total PCB, pesticides), biological treatment is not considered to be feasible. Thus, *ex situ* biological treatment will not be considered for further evaluation.

3.3.7.4 Technology Class: Thermal Treatment

Thermal Desorption. Thermal desorption is a treatment technology which is designed to remove contaminants from solid media by volatilizing them with heat at below-combustion temperatures [typically 200 degrees Fahrenheit (°F) to 1,000°F] in a primary chamber. The desorbed contaminants are then treated in a secondary unit to control air emissions. Many thermal desorption units are smaller, portable systems that may be inadequate for larger sized dredging projects. The efficiency of thermal desorption decreases with increased soil moisture content. Clay and silty soils and high humic content soils increase reaction time as a result of binding of contaminants (www.frtr.gov/matrix2/section4/4-26.html). In addition, since thermal desorption does not treat metals, the treated residue will need to be further processed to immobilize the metals. Since the sediments from the Area of Focus are mostly fine-grained and contain high concentrations of heavy metals, thermal desorption will not be retained for further evaluation.

Thermal Destruction. Thermal destruction is a controlled process that uses high temperatures (typically between 1,400°F and 2,200°F) to volatilize and combust organic chemicals. Thermal destruction has been demonstrated to be very effective in destroying organic contaminants such as PCDD/F, PCB, and PAH. The process is potentially implementable as there are several facilities in the United States (primarily in Texas and other western states) and Canada that are permitted to accept such waste materials.

The Cement-Lock® process described in Table 3-1g (attached) has been demonstrated to be effective in treating contaminated dredged sediments and in producing a beneficial use product. This beneficial use product is a construction-grade cement in which the non-volatile metals originally present in the sediment are bound via an ionic replacement mechanism (refer to Appendix H "Dredged Material Management Assessments"). Volatile heavy metals – such as mercury – are removed from the flue gas as it passes through a bed of activated carbon pellets. Thermal destruction is retained for further evaluation because it is one of the only technologies proven as effective in treating the organic COPCs and COPECs (*i.e.*, PCDD/F, PCB, and PAH) detected in the sediment of the Area of Focus.

Vitrification. Vitrification is a process in which higher temperatures (2,500°F to 3,000°F) are used to destroy organic chemicals by melting the contaminated dredged material to form a glass aggregate product. Vitrification has been demonstrated to be very effective in destroying organic contaminants such as PCDD/F, PCB, and PAH in dredged material. The vitrification technology has been commercialized by Minergy Corporation, which operates facilities in Neenah and Winneconne, Wisconsin, and is constructing another facility in Zion, Illinois (primarily for biosolids treatment). Currently no full-scale operating facility exists with sufficient capacity to accept large volumes of dredged material from the Area of Focus. Therefore, vitrification is considered for further evaluation, but construction of a new facility would potentially be required.

3.3.8 General Response Action: Beneficial Use of Dredged Sediments

Sanitary Landfill Cover. Sanitary landfills accept dredged material on a case-by-case basis. Given the restrictions placed on land disposal of PCDD/F-containing materials (refer to Appendix H "Dredged Material Management Assessments"), only a small portion of dredged material from the Area of Focus would likely be suitable for landfill cover. Nevertheless, because of the potential beneficial use of dredged material as compared to disposal options such as landfilling as a waste, use as sanitary landfill cover is retained for further evaluation.

Construction Fill. This beneficial use option may be suitable for dredged material with low concentrations of contaminants (especially if the dredged material is subjected to a relatively low-cost treatment such as solidification/stabilization) or for more contaminated dredged material that has been more aggressively treated. One example of such a project is the EnCap Golf Holdings, LLC redevelopment project in the Meadowlands area in New Jersey. Because of the potential beneficial use of dredged material as compared to disposal options such as landfilling as a waste, use as construction fill is retained for further evaluation.

Mined Lands Restoration. Dredged material can be beneficially used in the restoration of abandoned surface mined lands and to restore, protect, and enhance lands damaged by mining. The goal is to successfully use the dredged material to stabilize and re-vegetate the damaged lands, reduce acid mine drainage and restore the local ecosystem. Abandoned mine reclamation is an attractive beneficial use option because of the potential for placement of very large volumes of dredged material. It is estimated that the state of Pennsylvania's mine fill requirement is in excess of 10 billion cubic yards (New York/New Jersey Clean Ocean and Shore Trust and PaDEP, 2006). Determination of whether this option is implementable using dredged material from the Area of Focus would require consideration of whether contaminant concentrations meet NJDEP and Pennsylvania Department of Environmental Protection (PaDEP) requirements, availability of nearby sources of admixture, accessibility of the sediment processing site to rail, and acceptance by the local community. Many mined sites should have rail access so that transport of sediment can be achieved via rail car, which is more efficient than via truck. Given the effectiveness observed during the successful reclamation project at the Bark Camp Mine Reclamation Experimental Facility in central Pennsylvania [refer to Table 3-1h (attached)], and the potential for the acceptance of large quantities of sediment (*e.g.*, Springfield Pit), this option will be retained for further evaluation.

3.3.9 General Response Action: Disposal of Dredged Sediments

Options involving sediment removal from the Lower Passaic River will require some means of final placement after dewatering and/or treatment via *ex situ* techniques described above. Placement options considered include land disposal, aquatic disposal, and beneficial use (refer to Section 3.3.8 "General Response Action: Beneficial Use of Dredged Sediments").

3.3.9.1 Technology Class: Land Disposal

Land disposal of contaminated sediments may be accomplished in landfills or in upland CDFs. Upland CDFs may accommodate mechanically or hydraulically dredged sediments and can be designed and operated to accomplish both dewatering and encapsulation.

The LDR under the Hazardous and Solid Waste Amendments (HSWA) to RCRA must be considered for land disposal options. The LDR program identifies treatment standards to manage restricted wastes destined for land disposal.

<u>Off-Site Landfill</u>. Landfill acceptance of dredged material is determined on a case-by-case basis because permit requirements are facility-specific. Off-site landfill disposal in a local non-hazardous landfill may be effective and implementable for less-contaminated, untreated dredged material from the Area of Focus, or for more contaminated dredged material that has been treated to an acceptable degree. Off-site landfill disposal will be retained for further evaluation.

Upland CDFs. An upland CDF is an engineered structure enclosed by dikes, berms, or walls and specifically designed to contain dredged material. It may be considered as a final disposal site or as a temporary storage location prior to dredged material treatment. The main challenge to implementability of this process option is identifying and obtaining approvals for a site that is proximal and of sufficient size to accommodate the potentially large volumes of more highly contaminated dredged material to be generated. A summary of an upland CDF siting study performed by NJDEP is included in Appendix H "Dredged Material Management Assessments". Upland CDFs are retained for further evaluation.

3.3.9.2 Technology Class: Aquatic Disposal

If dredged material is removed but replaced in water within the Area of Contamination, which for this FFS includes the Lower Passaic River, Newark Bay, and areal extent of contamination, LDRs are not triggered.

CAD. Disposal of dredged material in open water CAD cells has been practiced for many years, primarily for navigational dredging projects. CAD involves subaqueous covering or capping of dredged material, whether simply placed on the bottom or deposited in depressions or excavated pits. Even for dredged material derived from navigation projects, CAD cells have been viewed unfavorably by the regulatory and environmental communities. Compared to nearshore CDFs, there is not nearly the potential for control of effluent, precise placement of the material into the CAD unit, nor the ability to minimize sediment resuspension. The presence of the Newark Bay CDF near the Elizabeth Channel demonstrates that this option is implementable[5], however recent usage has been limited to emergency projects or projects with a demonstrated hardship (*i.e.*, other cost-feasible options are not available). Furthermore, disposal in CAD cells would essentially eliminate the potential for temporary storage because of the impacts associated with placement and redredging for treatment. Therefore, CAD cells will not be retained for further evaluation.

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[5] Note that although it is referred to as a CDF, the Newark Bay facility is technically a CAD as defined in this document.

In-water CDF. A CDF may be constructed as an in-water site (*i.e.*, a containment island). An in-water CDF can be constructed with dikes or other containment structures to contain the contaminated dredged material, isolating it from the surrounding environment. Challenges to implementability include waterway impacts, such as disruption of circulation patterns, and the difficulty associated with construction and operation of an in-water CDF using marine-based equipment, especially if the CDF is used for dewatering and storage prior to treatment. In addition, in-water CDFs are difficult to site and present obstacles to obtaining regulatory approvals due to the required mitigation for impacts to benthic and aquatic habitat, Previous attempts to site in-water CDFs in the Port region have not succeeded, at least partially due to aesthetic concerns. For these reasons, in-water CDFs are not retained for further evaluation.

Nearshore CDF. A CDF may also be constructed as a nearshore site (*i.e.*, in water with one or more sides adjacent to land). In some cases, a nearshore CDF can be integrated with site reuse plans to both reduce environmental risk and simultaneously foster redevelopment in urban areas and brownfields sites (USEPA, 2005). Based on a preliminary inspection of land use and waterway characteristics, several potential sites for nearshore CDFs have been identified. These sites are amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any alternative and could also provide temporary storage for sediment to be treated at a later date. Nearshore CDFs are retained for further evaluation.

3.4 ANCILLARY TECHNOLOGIES

Additional technologies and process options that are ancillary to those retained process options presented in Section 3.3 "Technology Class Identification and Screening" may be incorporated in any remedial alternative implemented in the Area of Focus. They are described here in relation to their potential applicability to some of the primary technologies that are evaluated.

3.4.1 Sediment Dispersion Controls

Water-borne transport of resuspended contaminated sediment released during dredging can often be reduced by using physical barriers around the dredging operation area. Two of the more common approaches include silt curtains and sheet-pile walls.

Silt curtains are floating barriers designed to control the dispersion of sediment in a body of water. They are made of impervious flexible materials such as polyester-reinforced thermoplastic (vinyl) and coated nylon. The effectiveness of silt curtains and screens is primarily determined by the hydrodynamic conditions at the site. Conditions that may reduce the effectiveness of these and other types of barriers include the following: significant currents, high winds, changing water levels and current direction (*i.e.*, tidal fluctuation), excessive wave height, and drifting ice and debris (USEPA, 2005). Silt curtains are generally more effective in relatively shallow, undisturbed water. As water depth increases and turbulence caused by currents and waves increases, it becomes difficult to isolate the dredging operation effectively from the ambient water. Under ideal conditions, turbidity levels in the water column outside the curtain can be as much as 80 to 90 percent lower than those levels inside or upstream of the curtain (Francingues and Palermo, 2005).

Sheet-piling consists of a series of panels with interlocking connections driven into the ground with impact or vibratory hammers to form an impermeable barrier. Sheets can be made from a variety of materials such as steel, vinyl, plastic, wood, recast concrete, and fiberglass. Sheet-pile containment structures are more likely to provide reliable containment of resuspended sediment than silt curtains, although at significantly higher cost and with different technological limitations. Sheets must be properly imbedded into the subsurface to ensure that the sheet pile structure will withstand the hydraulic forces (*e.g.*, waves and currents). Sheet-pile containment may increase the potential for scour around the outside of the containment area. Also, resuspension may occur during placement and removal of these structures. In addition, use of sheet-piling may significantly change the carrying capacity of a stream or river and make it temporarily more susceptible to flooding (USEPA, 2005).

An alternative to sheet-piling is the *in situ* solidification/stabilization of sediments in an area to be dredged. The improvement of geotechnical properties of sediments in an area to be dredged may render the sediment more suitable for accurate dredging, and may also result in a stronger sediment bed which may not require sheet-pile to maintain sidewall stability during dredging operations. If successful, solidification/stabilization might have the benefit of reducing resuspension, as well as improving the handling characteristics of the sediment for transportation and disposal or treatment.

3.4.2 Dewatering

Dewatering involves reduction in the moisture content of dredged material to produce a material more amenable to handling with general construction equipment and that meets landfill disposal or treatment plant criteria (*e.g.*, paint filter test or percent moisture for thermal treatment). Selection of an appropriate dewatering technology depends on the physical characteristics of the material being dredged, the dredging method, and the target moisture content of the dewatered material.

The *ARCS Remediation Guidance Document* (USEPA, 1994) has classified dewatering technologies into three general types: passive dewatering, mechanical dewatering, and active evaporative technologies. These dewatering methods, as well as desiccation via amendment, are summarized in Table 3-2.

Table 3-2: Dewatering Methods

Category	Description	Methods	Advantages	Disadvantages
Passive	Relies on settling, surface drainage, consolidation, and evaporation to remove water	Settling basins with underdrains; tanks, lagoons, surface impoundments	Low cost	Large amounts of time and space required; not feasible for large dewatering projects; potential for air emissions
Mechanical	Input of energy to squeeze, press or draw water from sediments	Belt filter presses, plate filter presses, hydrocyclones, centrifuges	High processing rates, less time and space required	High operations and maintenance costs
Active evaporative	Artificial energy sources to heat sediments and remove moisture	Flash dryers, rotary dryers, modified multiple hearth furnaces	Can achieve the highest solids content (up to 90 percent)	High energy costs; capture and treatment of air emissions
Active amendment	Addition of pozzolanic material	Portland Cement, quicklime, grout, ash	Low cost, easily implementable	Increase in volume

Dewatering of significant amounts of dredged material requires a land-based staging area in close proximity to the dredging site. The area should be accessible to barges, large equipment, and trucks, and should incorporate security measures such as signage, fencing, and/or guard patrol to limit access by unauthorized personnel. Larger dewatering projects, even with mechanical dewatering systems, require large amounts of space. Plans for a dewatering facility should include details such as berms, runoff collection systems, and turbidity controls. Optimal dewatering system operating characteristics include: small footprint, high production rates, and low cost. The design of a dewatering system should be based on consolidation tests performed on material from the site to be dredged.

3.4.3 Wastewater Treatment

The purpose of wastewater treatment is to prevent adverse impacts of a dewatering effluent discharge on the receiving water body, which may be a permitted discharge to the Lower Passaic River or Newark Bay, a POTW, or an industrial wastewater facility. Mechanically dredged material typically has a solids content of approximately 25 to 50 percent by weight, while hydraulically dredged material is in the form of a slurry with a solids content typically in the range of 2 to 10 percent (the higher percentage generally applies to bank or surface material). Dewatering these dredged materials requires management of the contaminated dewatering stream to meet effluent water quality criteria for discharge to the receiving system. Therefore, a water treatment system would typically be included as part of the treatment train for the dewatering process. However, water quality may also be adversely impacted in and around dredging operations through resuspension and dispersion of contaminated sediments. The following sections briefly describe potential treatment trains to handle water from mechanically and hydraulically dredged material.

3.4.3.1 Mechanical Dredging Water Treatment.

Free water from mechanical dredging primarily accumulates within transfer barges or at the stockpile facility. Dredged material transfer barges may be left idle before offloading to allow for collection of free water at the surface of the load by dredged material consolidation. The free water can then be decanted and pumped ashore to a water treatment system, if necessary, prior to unloading the dredged material. An onshore water treatment system may consist of tanks for sedimentation, coagulation followed by secondary settling, and filtration or adsorption using sand or granular activated carbon.

3.4.3.2 Hydraulic Dredging Water Treatment.

Hydraulic dredging results in a large volume of sediment-water slurry to be managed. Passive dewatering is commonly applied for hydraulically dredged material. If suitable upland areas are not identified, other dewatering options would include passive dewatering in a nearshore CDF or by mechanical methods. Mechanical systems typically utilize screens and centrifuges for solids removal, in some cases aided by chemical coagulants and short-term gravity separation. Large tanks would be required to allow the addition of a coagulating agent to assist in secondary settling. As described above, depending on effluent criteria, the water would then be filtered and potentially passed through granular activated carbon to remove organic contaminants.

3.4.4 Transportation

A means of transportation will be required for any remedial alternative that involves removal of contaminated sediments from the Area of Focus. The transportation method included in each remedial alternative will be based upon the compatibility of that transportation method to the other process options. The most likely transportation methods are truck, rail, and barge. These are briefly discussed below. Appendix H "Dredged Material Management Assessments" includes a memorandum summarizing waterborne, rail, and road access associated with potential sediment processing or placement sites.

3.4.4.1 Truck

Truck transportation includes the transport of dewatered dredged material over public roadways using dump trucks, roll-off boxes, or trailers. This form of transportation is the most flexible, but can be very costly over long distances. Truck transport also has the greatest potential for impact on local streets and traffic, depending on the location of the processing facility with respect to major highways.

3.4.4.2 Rail

Rail transportation includes the transport of dewatered dredged material via railroad tracks using gondolas or containers. Rail transport is desirable where sediment is shipped over long distances, for instance, to out-of-state treatment or disposal facilities. Because rail transport requires coordination between multiple owners, and because many operators are unwilling to provide detailed information prior to entering actual negotiations, it is difficult to obtain accurate cost estimates. Rail transport may require the construction of a rail spur from a sediment handling facility to a commercial track.

3.4.4.3 Barge

Barge transportation includes the transport of dewatered dredged material via existing navigable waterways using barges. Barge transport would likely be used for short distances, such as from the dredging location to the dredged material handling facility. In addition, barge transport may be considered for longer distances if dredged material is hauled to out-of-state treatment or disposal locations that have the ability to accept barge-loaded dredged material.

3.4.5 Restoration

The implementation of a remedial alternative in the Area of Focus would impact existing habitat conditions. As part of the reconstruction of the remediated area, substrate would be placed that would be suitable for future activities relating to habitat construction. Certain types of restoration would likely be feasible to integrate with a remedial action, including riparian fringe restoration, mudflat reconstruction, and benthic habitat creation. In addition, biostabilization techniques could be considered as an alternative erosion protection measure and could have the added benefit of providing submerged aquatic or tidal emergent habitat.

The Study will also identify potential restoration opportunities (wetland creation, enhancement, *etc.*) that could be implemented following remediation beyond reconstruction to original grade. These activities are conducted as part of the WRDA function of the joint program. At present, there are efforts planned by the USACE to begin development of conceptual restoration plans as a companion to early action alternatives (refer to www.ourpassaic.org for additional information regarding restoration).

3.5 IDENTIFICATION OF RETAINED PROCESS OPTIONS

In addition to the No Action response, the following process options have been retained for further evaluation:

- Institutional controls, including, but not limited to, fish consumption advisories and dredging restrictions in shoal areas.
- Monitored natural recovery processes, including but not limited to burial, sedimentation, degradation, sorption, and oxidation.
- Containment via engineered caps and geotextiles.
- Sediment removal via excavation, mechanical dredging, and/or hydraulic dredging.
- *In situ* immobilization for the purposes of geotechnical improvements and resuspension control.
- *Ex situ* treatment via immobilization, sediment washing, vitrification, or thermal destruction.
- Beneficial uses including sanitary landfill cover, construction fill, brownfields remediation material, and mined lands reclamation.
- Disposal in an off-site landfill, upland CDF, or nearshore CDF unit.

4.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

The purpose of this section is to develop a set of remedial alternatives for remediation of contaminated sediment in the Area of Focus. The alternative development criteria described in Section 4.1 "Alternative Development Criteria" were considered when assembling remedial alternatives using the representative process options (described in Section 4.2 "Selection of Representative Process Options"). Conceptual designs for the active alternatives are presented in Figures 4-1 through 4-6.

The alternatives developed and screened in this FFS are conceptual. All characteristics of these alternatives (*e.g.*, sediment removal rates and depths, dredged material volumes, dredged material treatment facility throughputs, and bulk sediment chemical constituency) should be considered to be approximate for the purposes of a feasibility comparison only. Specific details would need to be finalized during a remedial design.

4.1 ALTERNATIVE DEVELOPMENT CRITERIA

The following sections present criteria that were considered during the development of remedial alternatives to treat contaminated sediment in the Area of Focus.

4.1.1 ARARs

Alternative development must conform to the requirements of CERCLA Section 121(d), which requires that Superfund remedial actions comply with federal and state ARARs, or justify a waiver. Refer to Section 2.0 "Development of Remedial Action Objectives and Selection of Target Areas" for more information regarding ARARs.

4.1.2 Statutory Preferences

CERCLA Section 121(b) identifies the following statutory preferences that must be considered in the development and evaluation of remedial alternatives:

- Remedial actions that involve treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances through treatment are preferred over remedial actions not involving such treatment.
- Off-site transport and disposal of hazardous substances or contaminated materials without treatment is considered the least favorable remedial alternative when practicable treatment technologies are available.
- Remedial actions using permanent solutions, alternative treatment technologies, or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in toxicity, mobility, or volume of a hazardous substance are preferred.

Remedial alternatives for the FFS were developed in consideration of these statutory preferences. They include source control remedies that seek to prevent or minimize the migration of hazardous contaminants. They have also been designed to reconstruct and monitor substrate for benthic and fish habitat in areas where short-term impacts to such habitat due to containment or removal actions are unavoidable to meet the RAOs.

4.1.3 Navigation Requirements

The Lower Passaic River contains a federally-authorized navigation channel (refer to Appendix F "Navigation Studies"). In RM0 to RM7, it is 300 feet wide and ranges in depth from 30 feet mean low water (MLW) to 16 feet MLW. In RM7 to RM8, it is 200 feet wide and 16 feet (MLW) deep. The most recent dredging in the river occurred in 1983, when approximately 540,000 cubic yards of sediment were removed from the lower portion of the river near Newark (Ianuzzi, *et al.*, 2002). Since that time, sediment deposition in the navigation channel has reduced the available draft to less than its authorized depth.

According to *Land Use in the CERCLA Remedy Selection Process* (USEPA, 1995), remedial alternatives developed during the RI/FS should reflect reasonably anticipated future land use(s). On the shores of the Lower Passaic River, land use and navigation use (and thus navigation channel depth) are very often linked. In order to evaluate the channel dimensions necessary to accommodate current navigation usage, USACE-New York District conducted a survey of commercial stakeholders along the Lower Passaic River. In order to evaluate the channel dimensions necessary to accommodate reasonably anticipated future usage of the river, the State of New Jersey conducted surveys of municipalities and other local organizations along the Lower Passaic River. Results of their evaluations are presented in Appendix F "Navigation Studies". Several active remedial alternatives were developed in consideration of these navigation requirements, which are described below.

4.1.3.1 Current Federally Authorized and Constructed Navigational Channel Depths

The current federally authorized channel depths of the commercially navigable portion of the Lower Passaic River are as follows:

- RM0 to RM2.5: The federally authorized and constructed channel depth is 30 feet relative to MLW. A bridge abutment at RM1.2 limits channel width to 145 feet. The Point-No-Point Swing Bridge at RM2.5 limits channel width to 103 feet and limits vertical clearance to 16 feet at high water.
- RM2.5 to RM4.6: The federally authorized and constructed channel depth is 20 feet MLW.
- RM4.6 to RM7.1: The federally authorized channel depth is 20 feet MLW; however, the channel was only constructed to 16 feet MLW.
- RM7.1 to RM8.1: The federally authorized and constructed channel depth is 16 feet MLW.
- RM8.1 to RM15.4: The federally authorized and constructed channel depth is 10 feet MLW.

As stated previously in Section 1.3.2 "CSM of the Lower Passaic River," since the 1940s there has been little maintenance dredging above RM2. Consequently, the channel has extensively filled back in, particularly between RM2 and RM8.

4.1.3.2 Navigational Channel Dimensions to Accommodate Current Usage

The USACE conducted an analysis of waterborne commerce conducted between 1980 and 2004 in the Lower Passaic River. The analysis concluded that over 90 percent of cargo transported along the river is carried in vessels loaded to less than 13 feet draft, with the exception of 13 records of vessels having 26-foot drafts in 2004. Because the bulk of these shipments occurred between RM0 and RM1.2 where the authorized and constructed depth is 30 feet, the analysis concluded that commercial navigation on the Lower Passaic River is most likely currently constrained by width rather than by depth. The width constraint is due to requirements associated with safe navigation: channel width should be at least five times the beam of the vessel for two-way traffic, and at least three times the beam of the vessel for one-way traffic, with beam defined as the width of a vessel at its widest point, usually midship.

Based on USACE data, the dimensions of a navigation channel within the lower eight miles of the Lower Passaic River that would accommodate the current usage are as follows:

- RM0 to RM1.2: The future authorized depth should be maintained at 30 feet MLW based on United States Waterborne Commerce data that indicate 13 barges requiring 26-foot drafts were recorded in 2004.
- RM1.2 to RM2.5: The future authorized depth should be a minimum of 16 feet MLW based on the 5.5-foot tidal range in the lower 2.5 miles of the Passaic River. Requiring shipments to coincide with high tide in order to maintain safe passage will impose operational limitations to the timing of commerce if the constructed depth falls below this authorized depth.

4.1.3.3 Navigational Channel Depths to Accommodate "Future Usage"

Channel depths to accommodate future usage were considered by the State of New Jersey and were based on future use surveys for municipalities, an evaluation of market and land use scenarios for the Passaic River Region, statewide economic and revitalization programs, as well as the USACE Navigation Analysis. The State's future usage recommendations are as follows:

- RM0 to RM1.2: The future authorized depth should be maintained at 30 feet based on United States Waterborne Commerce data that indicate a potential for increased use by vessels requiring 26-foot drafts.
- RM1.2 to RM2.5: The depth should not be less than 16 feet based on future industrial users, brownfields and portfields sites. Additional discussions need to take place among the State and the City of Newark and Kearny for this upper reach.
- RM2.5 to RM3.6: A minimum of 16 feet depth is required for this segment in order to preserve the potential for future navigational use and economic revitalization of the region.
- RM3.6 to RM4.6: The future authorized depth can be reduced to 10 feet, which will accommodate future ferry/water taxi operations planned for waterfront redevelopment in the City of Newark.
- RM4.6 to RM8: The future authorized depth can be reduced to 10 feet to support recreational vessels (with typical drafts of less than 3 feet) and water taxis.

4.1.3.4 Other Navigation Issues

In addition to navigation channel configuration, construction of berth areas is another component of navigation on the Lower Passaic River. Berth areas that have been historically dredged may contain thick silt deposits associated with contaminant inventory. Currently, locations of berth areas are unknown. Berth areas are likely to be addressed under local or state programs, although restrictions on dredging in capped areas would need to be imposed to maintain the integrity of the remedy.

4.2 SELECTION OF REPRESENTATIVE PROCESS OPTIONS

In addition to the No Action Response, seven general response actions were retained after screening remedial technologies in Section 3.0 "Identification and Screening of General Response Actions, Remedial Technology Classes, and Process Options." These general response actions, and the process options chosen to represent them for the purposes of the conceptual design and feasibility evaluations presented in this document, are discussed below.

It is important to note that the selection of representative process options presented below is for the purposes of this feasibility evaluation only, and that other process options may be identified and selected during a design phase.

- No Action: The No Action response does not include any containment, removal, disposal, or treatment of contaminated sediment. It does, however, assume the continuation of current institutional controls such as fish consumption advisories. It also includes the five-year remedy reviews required under CERCLA Section 121(c).
- Institutional Controls: It is likely that implementation of any remedial action would require the maintenance of existing institutional controls (*e.g.*, fish consumption advisories). Additional institutional controls such as restrictions or special conditions (*e.g.*, to protect cap integrity) imposed on private sediment disturbance activities could also be implemented as components of alternatives comprising active remedial measures.
- Monitored Natural Recovery: As discussed in Section 3.3.3 "General Response Action: Monitored Natural Recovery," MNR may not be effective as the sole component of an early action, but could be implemented as a component of alternatives comprising other active remedial measures.
- Sediment Removal: Three process options for sediment removal were retained in Section 3.0 "Identification and Screening of General Response Actions, Remedial Technology Classes, and Process Options" as being potentially implementable and effective for the Lower Passaic River: excavation, hydraulic dredging, and mechanical dredging. For the purposes of describing and estimating costs of remedial alternatives involving sediment removal, mechanical dredging has been selected as the representative process option. Mechanical dredging has been selected due to (a) the availability of site specific data regarding implementation, which was obtained during the Dredging and Decontamination Pilot Study (Thompson *et al.*, 2006), (b)

the additional challenges to implementability associated with the infrastructure needs for hydraulic dredging, and (c) the presence of extensive debris, which could present challenges to the effectiveness of hydraulic dredging.

- In Situ Treatment: In situ immobilization for improvement in sediment geotechnical properties was retained as a potential ancillary technology to other process options. In situ immobilization was not selected as a representative option in the development of remedial alternatives and costs for this feasibility evaluation; however, its use may be incorporated during a future design phase.
- Sediment Containment: As a result of the technology screening presented in Section 3.0 "Identification and Screening of General Response Action, Remedial Technology Classes, and Process Options," two process options for sediment containment were retained: engineered caps and geotextiles. Due to the large area being considered for remediation and the lack of precedent for implementation of a geotextile over such a large area, engineered caps have been selected as the representative process option for alternatives involving sediment containment.
- *Ex situ* Treatment: The *ex situ* treatment process options carried forward from Section 3.0 "Identification and Screening of General Response Action, Remedial Technology Classes, and Process Options" are immobilization, sediment washing, and thermal treatment via thermal destruction or vitrification. Each of these technologies could be applied to treat sediment from the Area of Focus; however, the treatment efficiencies vary depending on several factors, one of the most important of which is sediment contaminant concentration. The effectiveness of immobilization treatment is highly dependent on the initial sediment contaminant concentrations, and so it would be more suitable for sediment with lower contaminant concentrations. The treatment efficiency of sediment washing is a function of initial sediment contaminant concentrations, but also the class of contaminants that are present. Based on a recent pilot study (refer to Appendix H "Dredged Material Management Assessments"), certain classes of compounds are treated at higher efficiencies [*e.g.*, volatile organic compounds (VOCs)] and others are treated at a lower efficiency (*e.g.*, PAH). Thermal treatment generally provides the highest treatment efficiencies with the least sensitivity to initial sediment contaminant concentrations.

It is anticipated that several logistical issues would be encountered in attempting to segregate sediments from the Area of Focus based on contaminant concentrations. This is primarily because of the spatial heterogeneity in the contaminant distribution (refer to Appendix A "Conceptual Site Model"). Given the anticipated challenges for sediment segregation, the selected *ex situ* treatment process(es) must be capable of treating the highest concentrations of contaminants with the greatest efficiency. In addition, statutory preference is accorded to treatment technologies that permanently treat the hazardous substances through destruction of contaminants, reduction of total mass of contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media (USEPA, 1988). The thermal treatment process options, thermal destruction and vitrification, meet the criteria of permanently treating the sediments while achieving the highest treatment efficiencies. For purposes of developing the remedial alternatives and cost estimates, thermal destruction was selected as the representative *ex situ* treatment process option. Specifically, the Cement-Lock® process was selected since it produces a beneficial use product that offsets a significant portion of the treatment costs, and because it has been shown to achieve a high treatment efficiency for Passaic River sediments based on the results of a pilot demonstration in which 16.5 tons of Passaic River sediment were treated (refer to Appendix H "Dredged Material Management Assessments"). Additional treatment will be conducted and results evaluated in summer 2007.

- Beneficial Use of Dredged Sediments: Beneficial use options that have been considered include landfill cover, construction fill, brownfields remediation, and mined lands restoration. These options would entail immobilization treatment of dredged sediments to solidify, stabilize, and/or encapsulate contaminants. Given the complexities associated with segregating dredged material, and the uncertainties regarding the effectiveness of immobilization treatment for highly contaminated sediments, these beneficial use options have not been selected for use in remedial alternative development. It should be noted, however, that the representative *ex situ* treatment option (thermal destruction) results in a beneficial use end product. In addition, the representative disposal option of nearshore CDFs (see below) may provide a beneficial use through reclamation of nearshore land.

- Disposal of Dredged Sediments: The disposal process options that were carried forward from Section 3.0 "Identification and Screening of General Response Action, Remedial Technology Classes, and Process Options" include off-site landfills, upland CDFs, and nearshore CDFs. Upland and nearshore CDFs offer the advantages of being used either as final disposal sites or as temporary rehandling sites for storage or processing prior to sediment treatment. Nearshore CDFs have the added benefit of being in water within the Area of Contamination (which is the Lower Passaic River, Newark Bay, and areal extent of contamination), so that LDRs would not be triggered. In addition, nearshore CDFs are easier to integrate with dredging (*e.g.*, it would be easier to transport and to offload dredged material to a nearshore CDF as opposed to an upland CDF). Therefore, nearshore CDFs have been selected as the representative process option for disposal of dredged sediments.

4.3 DEVELOPMENT OF REMEDIAL ALTERNATIVES

In addition to the No Action alternative required for evaluation under the NCP, the following alternatives have been developed as potential remedial actions for contaminated sediment in the Area of Focus:

- Alternative 1: Removal of Fine Grained Sediment from Area of Focus.
- Alternative 2: Engineered Capping of Area of Focus.
- Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel.
- Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage.
- Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage.
- Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from the Primary Erosional Zone and the Primary Inventory Zone.

The bases and assumptions used for conceptual design of these alternatives are discussed below in Section 4.3.1 "Bases for Concept Development." In addition, a detailed description of each alternative is presented in Section 4.3.2 "Remedial Alternative Descriptions."

4.3.1 Bases for Concept Development

This section identifies the bases and assumptions associated with the selected process options discussed in Section 4.2 "Selection of Representative Processes Options," which were used to conceptually design the alternatives identified in Section 4.3 "Development of Remedial Alternatives."

4.3.1.1 No Action

The No Action response does not include any containment, removal, disposal, or treatment of contaminated sediment. It does, however, assume the continuation of current institutional controls such as fish consumption advisories. It also includes the five-year remedy reviews required under CERCLA Section 121(c).

4.3.1.2 Monitored Natural Recovery

As discussed in Section 3.3.3 "General Response Action: Monitored Natural Recovery," MNR may not be effective as the sole component of an early action, but could be implemented as a component of alternatives comprising other active remedial measures. Once active remediation is completed, deposition of contaminated sediment, originating from freshwater flow over Dundee Dam and tidal exchange with Newark Bay, would subsequently control contaminant concentrations on the sediment surface in the Lower Passaic River. Natural recovery processes would serve to reduce the degree of contamination associated with these deposited solids. For more information, refer to Appendix D "Empirical Mass Balance Model."

4.3.1.3 Sediment Removal

Mechanical dredging of contaminated sediments could involve the following steps:

- Dredging targeted sediments using a mechanical dredge fitted with an environmental clamshell bucket.
- Transporting the sediments to a processing or storage facility.
- Processing the dredged material (*e.g.*, dewatering, desiccating, and/or stabilizing).
- Transporting the processed dredged material either for further treatment (*e.g.*, thermal treatment) and/or for placement (*i.e.*, disposal and/or beneficial use).
- Backfilling or capping of the dredged area.

Several major feasibility considerations drive the conceptual design, cost estimation, and feasibility evaluation of alternatives involving dredging. These considerations, and the relevant assumptions and bases used to address them, include:

- Productivity: Based on the results of the Dredging and Decontamination Pilot Study (Thompson *et al.*, 2006), which utilized an environmental dredge equipped with an 8 cubic yard clamshell bucket to dredge sediments from the area near RM3 of the Lower Passaic River, the production rate for one dredge has been assumed to be 2,000 cubic yards per 24-hour day.
- Accuracy: The results of the Dredging and Decontamination Pilot Study (Thompson *et al.*, 2006) indicated that over 65 percent of the targeted area was dredged to within six inches of the target elevation for single pass production dredging. Therefore, a vertical accuracy of six inches has been assumed, and a one-foot over-dredging allowance is used for volume estimates.
- Resuspension: Based on an evaluation presented in Appendix E "Engineering Memoranda," dredge area containment has not been utilized in the conceptual development of alternatives involving dredging. However, it is assumed that best management practices and state of the art technology would be employed with the objective of minimizing resuspension.
- Residuals: As soon as practicable after removal of dredged sediment from each dredge cell, backfill or capping material would be placed over the dredged area to cover the exposed surface and dilute the residual layer. Based on inspection of sediment profile imagery collected during the Dredging and Decontamination Pilot

Study, the thickness of the dredging residual layer is assumed to be up to six inches. Therefore, placement of a backfill layer with thickness of two feet is assumed.

- Dredged Material Management: Appendix H "Dredged Material Management Assessments" provides information and analysis of dredged material management issues.

4.3.1.4 Sediment Containment

Several major feasibility considerations drive the conceptual design, cost estimation, and feasibility evaluation of alternatives involving containment. These considerations, and the relevant assumptions and bases used to address them, include:

- Cap Material: Significant quantities of cap material will be required for alternatives involving containment. For the purposes of estimating costs, it is assumed that a nearby borrow source (either subaqueous or land-based) of coarse-grained sand will be available. In light of the results of modeling of potential cap erosion (refer to Appendix G "Cap Erosion and Flood Modeling"), the analyses performed to evaluate the feasibility of containment alternatives have been based on the characteristics of sand conforming to NJDOT specification I-7 (www.state.nj.us /transportation/eng/specs/english/EnglishStandardSpecifications.htm#s90120).
- Cap Placement: It is assumed that cap material will be placed on the river bed using conventional equipment, either by hydraulic diffuser or clamshell bucket.
- Cap Thickness: The conceptual design of an engineered cap in the Lower Passaic River, in accordance with USEPA guidance, takes into account various requirements for cap thickness. These requirements are presented in Figure 4-7 for the different cap concepts used in developing the alternatives.

  - Thickness for chemical isolation (T_i): Based on the primary goal of reducing particle-bound contaminant flux, a chemical isolation thickness of 12 inches was assumed.

- Thickness for consolidation (T_c): Based on the granular, poorly-graded nature of the representative material used for analysis, it is unlikely that significant consolidation of the cap material itself would occur. It is likely that some consolidation of the underlying material would occur, and a thickness of 6 inches has been assumed to account for this (refer to Appendix E "Engineering Memoranda").
- Thickness for bioturbation (T_b): Based on reporting from community surveys that is still undergoing USEPA review (Tierra Solutions, Inc., 2006), in nearby areas of the New York-New Jersey Harbor Estuary, it has been assumed that the benthic community that might recolonize capped areas would be unlikely to burrow to depths greater than 6 inches. If other species with deeper burrowing characteristics (*e.g.*, American Eel) were to colonize the capped area, sufficient thickness exists beyond the bioturbation layer to maintain the integrity of the cap despite burrowing.
- Thickness for settlement (T_s): Some settlement of the cap materials into the existing material may occur. However, literature suggests that use of hydraulic diffuser equipment can minimize this settlement; hence, no additional cap thickness has been assumed for settlement.
- Thickness for erosion (T_e): It is assumed that if 6 inches of erosion of capping material were to occur, cap maintenance activities would be initiated. In addition, armor material would be placed in areas prone to unacceptable erosion. Therefore, for areas in which a cap would be constructed only of sand, six inches has been assumed as an acceptable thickness for the erosion component; for areas in which a cap would be armored to withstand erosive forces, the thickness for the erosion component would be zero, as no erosion of sand material from underneath the armor layer would be expected (refer to Appendix G "Cap Erosion and Flood Modeling").

- Sand Cap Erosion/Armor Layer: The nature of a granular cap placed over the bed of a large, tidally influenced riverine system is inherently dynamic. Under normal tidal conditions, and particularly during extreme flow events, the granular material is expected to migrate to some extent. To investigate the nature of migration of an engineered sand cap placed in the Lower Passaic River, and to determine whether the extent and rate of migration are acceptable or require that an armor layer be placed, cap erosion modeling was conducted as described in Appendix G "Cap Erosion and Flood Modeling." Based on the results of this modeling, certain capped areas in the river would require armoring to reduce the erosion of the sand material. These areas were selected based on the threshold of approximately 1 inch of maximum erosion under the 100 year flow event. Using USACE guidance, a median stone size (d_{50}) for this armor material of 6 inches has been determined as suitable (refer to Appendix E: "Engineering Memoranda"). Placement of a stone of this size would require that the thickness of the armor layer be approximately 18 inches to ensure adequate coverage of the sand, and may require that a filter material be placed on the sand prior to stone placement to prevent settlement of the stone into the sand.

- Cap Extent: Generally, the cap extent for alternatives involving containment encompasses the entire Area of Focus; however, due to the depositional nature of portions of the river, it is possible that discrete areas within the river could be shown to be reliably depositional (even under storm flows).
- Navigation: The construction of a navigation channel in the Lower Passaic River would require the removal of sediment to at least the desired navigation depth, and the volume of material removed would depend on the dimensions of the channel to be constructed. In addition, in areas requiring placement of an engineered cap, removal below the desired navigation depth in order to accommodate the necessary cap components would be required. Table 4-1 (attached) portrays these cap components and the associated depth of removal required. In the case where applying the dimensions shown on Table 4-1 would remove all fine-grained sediment, the depth of removal is limited to the depth of historical dredging (*e.g.*, navigation channel depth plus two feet) and the area would be remediated by dredging and backfilling instead of capping. For example, in a case where the depth of the proposed navigation channel will be 16 feet in a location where the constructed channel is 30 feet, the depth of removal would be 25 feet (*i.e.*, 16 feet plus 8 feet for cap construction plus 1 foot of overdredge allowance for inclusion in the volume estimate) and the location

would be capped. Alternatively, in a case where the depth of the proposed navigation channel will be 16 feet in a location where the constructed channel is 20 feet, the depth of removal would be 23 feet (*i.e.*, 20 feet plus 2 feet of historical overdredging plus 1 foot of overdredge allowance for inclusion in the volume estimate) and the location would be backfilled rather than capped.

- Flooding Issues: To determine whether the placement of an engineered sand cap with armor would result in additional flooding impact to the area surrounding the Lower Passaic River, an analysis was conducted to evaluate the response of the water surface elevation in the Lower Passaic River to the modified bathymetry and roughness associated with alternatives involving containment (to reflect the placement of an engineered cap) and to the hydrodynamic conditions present during an extreme event. This analysis is described in Appendix G "Cap Erosion and Flood Modeling" and summarized in Table 4-2. Based on guidance for remediation of contaminated sediments (USEPA, 2005), this analysis focuses on the 100-year storm. The results of the flood modeling demonstrate that changes in the bottom roughness and/or bottom elevation can impact the total area flooded.

Table 4-2: Total Areas (acres) Flooded Under Different Remedial Scenarios

	Base Case (Existing Conditions)	8-Mile Cap (Armor Area Predredging)	8-Mile Cap (Full Predredging)	Current Navigation Usage (Full Predredging)	Future Navigation Usage (Full Predredging)
100-Year Flow Event	499	592	523	523	482
500-Year Flow Event	794	880	822	822	767
100-Year Surge Event	1,249	1,249	1,249	1,249	1,249
500-Year Surge Event	1,504	1,504	1,504	1,504	1,504

Source: HydroQual Environmental Engineers & Scientists, 2007 (see Appendix G: "Cap Erosion and Flood Modeling" for full report).

- Pore Water Fluxes: Groundwater contaminant flux is probably a relatively minor contributor of hydrophobic contaminants to the river, as compared to sediment resuspension and transport, even when the ability of dissolved organic compounds to enhance that groundwater flux is taken into account. This evaluation is based on professional judgment and the Lower Passaic River sediment's high organic content, because there is limited groundwater data for this river. Additional detail is provided in the CSM (Appendix A "Conceptual Site Model"). The conceptual cap design presented does not consider the treatment of groundwater or porewater.

- Prop Wash: Erosive forces associated with engine prop wash have not been evaluated in detail; however, incorporation of a buffer zone [as shown on Table 4-1 (attached)] should minimize impacts to a cap.
- Ice Scour: A limitation in colder regions is the potential erosion of a cap due to ice jam formations. According to the Cold Regions Research and Engineering Laboratory (CRREL) Ice Jam Database, there have been three ice jam events recorded in the Passaic River at Chatham, New Jersey in the freshwater section of the river. Although ice forms in the Lower Passaic River, no records of ice jams were found in the Area of Focus. Therefore, cap erosion due to ice jams is not considered a major concern for the Area of Focus. Although ice scour at the shoreline could be an issue, it could be mitigated via biostabilization or installation of armoring materials at the shoreline.
- Wind/Wave Effects: The effects of wind/wave action on cap stability have not been evaluated. Open water, deeper sites will be less influenced by wind or wave generated currents and are generally less prone to erosion than shallow, nearshore environments. However, armoring techniques or selection of erosion resistant capping materials may make capping technically feasible in some higher energy environments.

4.3.1.5 Ex Situ Treatment

Thermal destruction has been selected as the representative process option for *ex situ* treatment because of the high treatment efficiencies for the types and concentrations of contaminants present in the Area of Focus. Several thermal treatment options were considered in developing conceptual remedial alternatives and cost estimates, as discussed below:

- Construction of a local thermal treatment facility: It is assumed that a local thermal treatment facility would be constructed on the same property as the sediment processing facility at a near-river location. It has been assumed that capacity of the facility, if constructed, would be sufficient to accept all material requiring treatment, such that no other treatment options would be required. Cost estimates for construction and operation of thermal treatment facilities of varying capacities were obtained from thermal treatment vendors.
- Transport to an existing, off-site, domestic facility: A limited number of domestic thermal treatment facilities are capable of accepting PCDD/F-containing material. Cost estimates associated with this thermal treatment option were based on rail transport of contaminated sediments to permitted facilities in Deer Park, Texas and Port Arthur, Texas. The facility in Deer Park, Texas is operated by Clean Harbors, and has a capacity of approximately 250 tons per day. The Port Arthur facility is operated by Onyx, and has a capacity of approximately 400 tons per day. Both of these facilities are served by rail and have the required permits to treat PCDD/F-contaminated sediment, provided that the sediment is not an F-listed PCDD/F waste. For this analysis, it was assumed that each facility could dedicate approximately 40 percent of their daily capacity to the Lower Passaic River, so that the Deer Park facility could accept 100 tons per day, and the Port Arthur facility could accept 150 tons per day. This quantity equates to a total domestic thermal treatment capacity of approximately 90,000 tons per year.
- Transport to an existing, off-site, international facility: Bennett Environmental operates a thermal treatment facility capable of treating PCDD/F-containing waste. Cost estimates are based on rail transport to the facility located in Ontario, Canada, which has an annual capacity of 100,000 tons per year. For this analysis, it is assumed that Bennett could dedicate 100 percent of their capacity to treating material from the Lower Passaic River.

It is important to note that for projects utilizing multiple dredges, the combined use of both existing domestic and existing international facilities may not be sufficient to treat all of the contaminated sediments (*i.e.*, the volume of sediment deemed to require thermal treatment based on a material stream distribution analysis). Although storage space could offset the deficit in throughput capacity, facility operators have indicated that off-site storage capacity is minimal. Given the uncertainties associated with throughputs for off-site thermal treatment facilities, it has been assumed that a local thermal treatment facility would be constructed to treat the dredged sediment. For purposes of remedial alternative and cost estimate development, it has been assumed that the Cement-Lock® thermal process would be applied.

It would be necessary to dewater the dredged material prior to thermal treatment. The average *in situ* sediment solids content measured by sediment coring associated with the Dredging and Decontamination Pilot Study was approximately 42.5 percent (TAMS and Malcolm Pirnie, Inc., 2005a). Mechanical dredging will result in additional water entrainment, lowering the percent solids of the recovered sediment. Therefore, for cost estimating purposes, it was assumed that the initial solids content of the dredged sediment is 25 percent, and that the post-dewatering solids content is 50 percent.

4.3.1.6 Disposal of Dredged Sediments

As discussed in Section 4.2 "Selection of Representative Process Options," nearshore CDFs have been selected as a process option for sediment disposal. Construction of a CDF would require containment measures such as sheet-piling. The CDF could be used for storage and passive dewatering of dredged sediment. A leachate collection system could be constructed to collect and channel effluent to a treatment system. As a final use, the dewatered sediment in the CDF could be removed for thermal treatment, or it could be permanently capped to create land for a beneficial use such as a park or development. One advantage of using a nearshore CDF for temporary storage is that a smaller thermal treatment plant could be constructed at a lower capital cost and sediment could be treated over a longer time. With an assumed footprint of 100 acres and a depth of 10 feet, a nearshore CDF could accommodate approximately 1.7 million cubic yards of sediment. If the CDF were to be excavated by 20 feet, 40 feet, or 60 feet, it could accommodate approximately 5 million, 8 million, and 11 million cubic yards of sediment, respectively. These volumes would accommodate the sediment capacity required for each remedial alternative discussed in Section 4.3.2 "Remedial Alternative Descriptions" below. For costing purposes, it is assumed that for alternatives where additional capacity is required (beyond the 10-foot initial depth), the first five feet of excavated material is assumed to be contaminated, and it would be dredged and placed in a 'starter cell' of the CDF. Any additional deeper material could be dredged and disposed of in an ocean disposal area.

Two dredged material management scenarios incorporating nearshore CDF disposal are considered in developing the alternative specific cost estimates presented in Appendix J "Cost Estimates." Dredged Material Management Scenario A assumes that all dredged material would be permanently disposed of in a CDF. Dredged Material Management Scenario B assumes that all dredged material would initially be placed in a CDF, but the volume stored above the original mudline grade (prior to excavation within the CDF footprint), would be dewatered and treated by an onsite thermal treatment facility. The volume to be thermally treated under Scenario B is up to approximately 1.7 million cubic yards. When necessary to provide the required capacity, excavation below the mudline (within the footprint of the CDF) would be performed.

One additional dredged material management scenario that could be considered is treating all dredged material via thermal destruction. For alternatives where dredging volumes are low (i.e., Alternatives 2 and 4), the cost difference between CDF disposal and thermal treatment is minimal (the thermal treatment cost is offset by capital savings for the construction of the CDF). For alternatives where greater volumes are generated (i.e., Alternatives 1, 3, 5, and 6), the additional cost for thermal treatment of all material is approximately \$30 to \$40 per cubic yard (on an in situ basis) above the cost of dredged material management Scenario B.

4.3.1.7 Additional Considerations

This section discusses additional elements of the remedial alternatives that are not considered process options, but that are considered integral parts of the remedial action alternatives. These items are included in all active alternatives and their associated costs are provided in Appendix J "Cost Estimates."

Pre-Design Investigation: The purpose of the pre-design investigation would be to provide current data on sediment conditions prior to initiation of remedial design. The pre-design investigation program would involve sediment sampling for chemical and geotechnical parameters. For alternatives involving sediment removal, it is assumed that cores for chemical analysis would be collected on an 80-foot triangular grid, and cores for geotechnical analysis would be collected on a 160-foot triangular grid. For alternatives involving containment, it is assumed that cores for both chemical and geotechnical data needs would be spaced on a 160-foot triangular grid (cores for chemical analysis will be collected only from areas of planned sediment removal). Coring depths for chemical and geochemical samples would vary depending on the planned sediment removal depth for each alternative, and depending on whether shoreline and utility protection structures would be utilized. Details regarding assumed depths of cores and numbers of samples to be collected per core are included in the cost estimate assumptions provided in Appendix J "Cost Estimates." Geophysical data including sediment type, texture, thickness, and elevation would be collected using techniques such as cone penetrometer testing (CPT), side-scan sonar and bathymetric surveys of the target area. A video survey would be incorporated in the pre-design investigation to identify debris in the target area.

Permitting, Design, and Contractor Work Plans: Permitting for an early action, if selected, would begin during the pre-design investigation phase, and should be completed prior to the start of construction. Typically, CERCLA response actions are exempted by law from the requirement to obtain federal, state, or local permits related to any activities conducted completely on-site; however, this exemption does not remove the requirement to meet (or waive) the substantive provisions of the regulations that are ARARs. Also, permits may be required for dredged material management facilities that are not located 'on-site'.

Upon completion of the pre-design work, a final design incorporating specifications and drawings would be prepared, and a contractor would be selected to perform the construction work. The contractor would be required to prepare its work plans detailing operational parameters for equipment to be used, quality assurance and quality control procedures, safety procedures, work schedules, and other items, as required. The costs for contractor work plans are based upon the size of the projects proposed in each remedial alternative.

<u>Mobilization/Demobilization and Annual Shutdown/Startup:</u> After completion of pre-construction activities, the contractor would mobilize required equipment to the site. For cost estimation purposes, it is assumed that the type, size, and number of equipment and monitoring vessels is assumed to vary based on the processes utilized for each alternative. The types of equipment and vessels that may be mobilized include the following:

- Dredges.
- Scows for holding and transporting dredged material.
- Clamshell buckets, diffusers, or spreaders for cap placement.
- Steel sheeting and barge-mounted vibratory hammer for alternatives involving shoreline protection. (It is assumed that, in areas of existing bulkheads and shoreline structures, as well as bridge abutments, protection via sheet-pile would be utilized.)
- Debris removal equipment.
- Hydrographic survey vessels.
- Geophysical vessel(s).
- Sampling (Vibracoring) vessel(s).

Demobilization involves removing all equipment from the staging and work areas and meeting any requirements for decontamination or verification of the acceptable status of the processing areas. It is assumed that full demobilization will not be required every year; however, to account for the potential for an extended period of seasonal or weather-related downtime, the cost of an annual shutdown/startup of construction operations has been included.

Debris Management: Prior to implementing any remedial activity, it would be necessary to remove large debris from the sediment surface to streamline subsequent dredging and/or capping operations. A side-scan sonar survey performed by Aqua Survey, Inc. (2006) in 2004, identified 47 large objects, 16 of which had signatures of automobiles. A shipwreck was also identified. These data were used as a rough indication of the amount of debris that may be encountered for purposes of the cost estimate. Further, to account for the possibility of sub-surface debris not identified by the side-scan sonar survey, the quantity of debris requiring removal was assumed to increase corresponding to an increase in depth of sediment removal. It was assumed that debris removal would proceed at a rate of approximately 100 tons per day until the estimated quantities were removed, and that the debris would be classified as non-hazardous waste. Estimates of debris removal quantities and management costs are provided in Appendix J "Cost Estimates." A video survey would be performed during the pre-design investigation to refine the debris management estimates.

Dredged Sediments Processing Facility: The characteristics of a suitable sediment processing location include adequate river frontage for supporting barge operations, sufficient land for materials processing and storage, and access to rail facilities. For purposes of the cost estimate, it is assumed that a waterfront processing facility will be located within the Port of New York and New Jersey district.

A preliminary study was conducted to identify potential sites for the development of either a processing facility or placement site to handle dredged material from the Lower Passaic River (USACE, 2006b and Appendix H "Dredge Material Management Assessments"). The extent of the study covered a 15-mile radius around the waterfront portions of the area between RM2.4 and RM4.6 of the Lower Passaic River. Factors influencing potential site identification included site accessibility and land use. Water, rail, and road access were evaluated for each site, including presence of piers/bulkheads, water depths, paved roads, proximity to major highways, and distance to rail lines or spurs. Land use considerations included the existence of vacant lots, open space, and degree of development. Other considerations included confirmation of loading/docking facilities, nearby bridge heights, and location of residential areas.

A total of 87 potential placement or processing sites were identified within the extent of the study. Nineteen large (greater than 50 acres) sites were identified. Of these, eight sites are within ten miles of the area between RM2.4 and RM4.6. There exist several sites of suitable size within an acceptable distance of the Lower Passaic River so as to be considered potentially feasible as processing or placement sites. Future site screening will be necessary in order to narrow down site location options and distinguish those sites with characteristics most desirable for processing and those sites with characteristics most desirable for placement.

Scows would deliver the dredged material to the processing facility. Material in the scows would be off-loaded by conventional methods such as a crane or excavator. Prior to unloading the scows, excess water that has accumulated above the incoming sediments would be pumped off, treated, and discharged back to the river (or other adjacent water body or POTW). Once the dredged material has been off-loaded, it would be processed to improve its handling and shipping characteristics. The precise nature and degree of processing would depend on sediment characteristics, and the requirements of the applicable dredged material management option (*i.e.*, thermal treatment or placement).

<u>Construction Monitoring Program:</u> Development of the construction monitoring program is based on the resuspension monitoring procedures used for the Environmental Dredging Pilot Study (TAMS and Malcolm Pirnie, 2005b; Bilimoria *et al.*, 2006). Appropriate data quality objectives (DQOs) for the construction monitoring program would be developed during the design phase of the project.

During the construction period, water quality in the vicinity of construction operations would be monitored. It is assumed that two sampling vessels, one positioned upstream and one downstream of the construction equipment, would be used to collect water quality samples. All of the surface water samples would be analyzed for total suspended solids, and a subset of samples may also be analyzed for a limited suite of other water quality parameters or contaminants of concern.

Confirmatory sampling for alternatives involving placement of backfill or capping material would be implemented to document a sufficient thickness of material and characterize the contaminant distribution at and around the interface between the existing sediment and cap material. This task has been estimated assuming that 4-foot cores would be taken at a frequency of 5 cores per transect placed at 0.1-mile intervals.

The depth of sediment removed as well as the depth of backfill or capping material placed would also be monitored using methods such as CPT, bathymetry, and acoustic imaging of the sediment type (side-scan sonar).

Ecological monitoring would be performed during the course of construction to assess the impact on the biological community within the Area of Focus, as well as upriver and downriver of this area. Monitoring would include terrestrial, avian, and aquatic (*i.e.*, fish, benthic, and submerged vegetative) communities, as well as biological tissue analysis and toxicity testing.

Post-Construction Monitoring Program: A post-construction monitoring program would be performed for each alternative. Based on USEPA guidance, costs are included for a period of thirty years of monitoring for each alternative (USEPA, 1988). Appropriate DQOs would be developed during the design phase. The purpose of the post-construction monitoring program would be to document the performance of the selected remedial measures in reducing COPC and COPEC concentrations in the water, sediment, and biota associated with the Lower Passaic River. Therefore, for the purposes of conceptual design and cost estimation, this program involves the sampling of all three media. For surface sediment sampling, it is assumed that five samples are collected per transect, spaced at 0.1-mile intervals throughout the Area of Focus. The water quality program is assumed to entail the collection of two surface water samples taken for 2 tidal cycles per river mile. Ecological monitoring would be performed to identify the impacts of the construction on the habitat and biological communities, and the changes and recovery that occur over the 30 year monitoring period. Avian, fish, benthic, and biological tissue samples would be collected at appropriate locations and frequencies. Each year, the post-construction ecological monitoring data would be assessed to determine if certain aspects of the program may be reduced to biannual (or less frequent) monitoring during future sampling events, or if the analyte list may be reduced. Additional details for the ecological monitoring program would be developed in an Ecological Monitoring Plan.

Techniques such as CPT would be conducted at least annually to monitor changes in the installed fill and capping material to identify areas undergoing scour or deposition. These data would be used to assess the long-term integrity of the cap for alternatives involving capping. Additional cap material would be placed in those areas in which the thickness of the cap is observed to have decreased by 6 inches or more to maintain a suitable cap thickness. In addition, sediment profile imaging (SPI) would be performed to monitor habitat recolonization.

<u>Restoration:</u> The implementation of a remedial alternative in the Area of Focus would impact existing habitat conditions. As part of the reconstruction of the remediated area, substrate would be placed that would be suitable for future activities relating to habitat restoration. Certain types of restoration would likely be feasible to integrate with a remedial action, including riparian fringe restoration, mudflat reconstruction, and benthic habitat creation. In addition, biostabilization techniques could be considered as an alternative erosion protection measure and could have the added benefit of providing submerged aquatic or tidal emergent habitat.

At present, there are efforts planned by the USACE to develop a Focused Restoration Plan as a companion to early action alternatives (refer to www.ourpassaic.org for additional information regarding restoration).

4.3.2 Remedial Alternative Descriptions

In this section, each of the six active remedial alternatives introduced in Section 4.3 "Development of Remedial Alternatives," and developed using the bases and assumptions provided in Section 4.3.1 "Bases for Concept Development," is described in detail. Table 4-3 (attached) provides a summary of the remedial alternatives.

4.3.2.1 Alternative 1: Removal of Fine Grained Sediment from Area of Focus

Alternative 1 would use mechanical dredging to remove fine-grained sediment from the Area of Focus.

Within the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment corresponds well with the depth of historical dredging. For this reason, the depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot).

Outside of the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment varies. Therefore, data from geotechnical cores and chemical cores were used to estimate the depth of the fine-grained sediment boundary at various locations in the river. The depth of dredging at each of these locations is the estimated depth of fine-grained sediment plus an additional one foot to account for dredging accuracy.

The objective of Alternative 1 is to remove as much of the fine-grained sediment as practicable, resulting in the exposure of the underlying sandy material. As soon as practicable after exposure of this sandy material, two feet of backfill material would be placed to mitigate residual contamination. The thickness of this backfill material would not be monitored or maintained following implementation.

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The dredged material removed during implementation of Alternative 1 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment, or it may be permanently capped in place.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify that the river is responding with reduced contamination levels over the long term. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 1 is shown on Figure 4-1. Additional detail is also provided in Table 4-3 (attached).

4.3.2.2 Alternative 2: Engineered Capping of Area of Focus

Alternative 2 would sequester the contaminated sediments in the Area of Focus under an engineered cap. Minimal removal of contaminated sediments, for the purposes of mudflat reconstruction and armor placement only, is assumed for Alternative 2.

The cap would be constructed of sand, stone, and mudflat reconstruction material. Over approximately 80 percent of the sediment surface area, the cap would be constructed of sand alone. In areas of unacceptable erosion, estimated to be approximately 20 percent of the river surface in Appendix G "Cap Erosion and Flood Modeling," stone would be used as armor material. In select small areas of the river, existing mudflats would be reconstructed by removing four feet of contaminated sediment, placing two feet of sand as substrate, and placing two feet of mudflat reconstruction material.

It has been assumed that placement of sand material would be conducted using conventional methods, which would be capable of minimizing the amount of settlement of the sand material into the existing silt. Placement of armor material would be achieved using mechanical methods. Due to the proximity to shore, mudflat reconstruction material would likely be placed via mechanical equipment.

The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations").

Flood modeling as described in Section 4.3.1.4 "Sediment Containment" and Appendix G "Cap Erosion and Flood Modeling," has shown that pre-dredging prior to cap placement does not substantially reduce the total area flooded. Therefore, pre-dredging in areas to be capped has not been incorporated into Alternative 2.

The dredged material removed during implementation of Alternative 2 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment, or it may be permanently capped in place.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 2 is shown on Figure 4-2. Additional detail is also provided in Table 4-3 (attached).

4.3.2.3 Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel

The dimensions of the federally authorized navigation channel are provided in Section 4.1.3.1 "Current Federally Authorized and Constructed Navigational Channel Depths." Alternative 3 would use mechanical dredging to remove sediment from within the horizontal limits of the federally authorized navigation channel. The depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sediment surface between the bottom of the dredged channel and the existing sediment surface ("sideslope") would be constructed at a slope of 3 horizontal to 1 vertical (3H:1V).

After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine-grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine-grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

Outside of the horizontal limits of the federally authorized navigation channel, however, it is possible that additional, un-targeted contaminant inventory would remain in place. For this reason, it is assumed that an engineered cap would be placed on the sideslopes, as well as on the existing sediment surface between the channel and the shoreline ("shoal"). In areas of unacceptable erosion on the sideslopes and/or shoals, as identified in Appendix G "Cap Erosion and Flood Modeling," stone would be used as armor material. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations").

The dredged material removed during implementation of Alternative 3 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment, or it may be permanently capped in place.

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After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 3 is shown on Figure 4-3. Additional detail is also provided in Table 4-3 (attached).

4.3.2.4 Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage

As described in Section 4.1.3.2 "Navigational Channel Dimensions to Accommodate Current Usage," USACE-New York District has estimated the dimensions of the navigation channel necessary to accommodate current usage. Alternative 4 would use mechanical dredging to construct a channel of these dimensions, and subsequently place an engineered cap over the entire Area of Focus.

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (30 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sideslope would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. The sideslope would be constructed at a slope of 3H:1V. Following removal to the depth described above, it is possible that additional, un-targeted contaminant inventory could remain in place. Therefore, an engineered cap would be placed on the channel bottom. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations").

In the sideslope and shoal areas of RM0 to RM2.5, and throughout the rest of the Area of Focus from RM2.5 to RM8, it is likely that additional, un-targeted contaminant inventory would remain in place. Therefore, pre-dredging to accommodate an engineered cap would be necessary in these areas. In areas of unacceptable erosion, as identified in Appendix G "Cap Erosion and Flood Modeling," stone would be used as armor material.

The dredged material removed during implementation of Alternative 4 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment, or it may be permanently capped in place.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 4 is shown on Figure 4-4. Additional detail is also provided in Table 4-3 (attached).

4.3.2.5 Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use

As described in Section 4.1.3.3 "Navigational Channel Depths to Accommodate 'Future Usage,'" the State of New Jersey has estimated the dimensions of the navigation channel necessary for future river traffic. Alternative 5 would use mechanical dredging to construct a channel of these dimensions, and place an engineered cap or backfill over the Area of Focus.

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (30 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The channel sides would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two foot backfill layer would be placed to mitigate remaining fine grained sediment and/or dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance to achieve the channel depth of 16 feet MLW, plus an additional nine feet to accommodate the necessary cap components that would be placed. The channel sides would be constructed at a slope of 3H:1V. Following removal to the depth described above, it is possible that additional, un-targeted contaminant inventory would remain in place. Therefore, an engineered cap would be placed on the channel bottom. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations").

From RM2.5 to RM3.6, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (20 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sideslope would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM3.6 to RM8.3, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (seven feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. This alternative will require sediment removal to 19 feet MLW. However, the depth of the authorized historical channel from RM8.1 to RM8.3 is 10 feet. An addition of three feet to the authorized depth to account for historical overdredging (two feet) and dredging accuracy (one foot) result in a historical channel depth of 13 feet MLW (not 19 feet MLW). Since dredge depth is limited to the historical channel depth, it is assumed that sediment will be removed to a depth of 13 feet MLW from RM8.1 to RM8.3. Following removal to the depth described above (*i.e.*, 19 feet MLW from RM3.6 to RM8.1 and 13 feet from RM8.1 to RM8.3), it is possible that additional, un-targeted contaminant inventory would remain in place from RM3.6 to RM4.6; however, it is assumed that minimal fine-grained sediment would remain in the channel from RM4.6 to RM8.3. Therefore, an engineered cap would be placed on the channel bottom from RM3.6 to RM4.6 and a two foot backfill layer would be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals from RM4.6 to RM8.3. The side slope would be constructed at a slope of 3H:1V. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations"), but the backfill layer would not be maintained.

In the sideslope and shoal areas of RM0 to RM8, it is likely that additional, un-targeted contaminant inventory would remain in place. For this reason, it is assumed that an engineered cap would be placed in these areas. In areas of unacceptable erosion, as identified in Appendix G "Cap Erosion and Flood Modeling," stone would be used as armor material. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program (as described in Section 4.3.1.7 "Additional Considerations").

Flood modeling as described in Section 4.3.1.4 "Sediment Containment" and Appendix G "Cap Erosion and Flood Modeling" has shown that pre-dredging prior to cap placement would reduce the total area flooded to below the acreage flooded under the base case. Therefore, pre-dredging in areas to be capped has been incorporated into Alternative 5.

The dredged material removed during implementation of Alternative 5 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment, or it may be permanently capped in place.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 5 is shown on Figure 4-5. Additional detail is also provided in Table 4-3 (attached).

4.3.2.6 Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone

The conceptual design of Alternative 6 is identical to that of Alternative 5, with the exception that, in the Primary Erosional Zone and the Primary Inventory Zone, the depth of dredging is assumed to be the estimated depth of fine grained sediment plus an additional one foot to account for dredging accuracy.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while monitored natural recovery processes act to reduce the concentration of the remaining contamination until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

The conceptual design of Alternative 6 is shown on Figure 4-6. Additional detail is also provided in Table 4-3 (attached).

5.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed analysis of the remedial alternatives described in Section 4.0 "Development of Remedial Action Alternatives." In addition to the No Action alternative, the six active remedial alternatives presented in Section 4.3.2 "Remedial Alternative Descriptions" are evaluated.

Section 5.1 "Evaluation Process and Evaluation Criteria" presents a description of each criterion and a discussion of how each criterion will be applied to evaluate the remedial alternatives. As the six active remedial alternatives were developed using the same set of process options, this section often relies on a discussion of how criteria apply to these process options.

Section 5.2 "Analysis of Alternatives" presents a detailed analysis of the individual alternatives in reference to the evaluation criteria (see Table 5-1) and a comparative analysis to evaluate the relative performance of alternatives in relation to each evaluation criterion. Comparisons are made either between the set of active alternatives and the No Action alternative, or by comparing the active alternatives to one another.

5.1 EVALUATION PROCESS AND EVALUATION CRITERIA

Nine criteria are used to address the CERCLA requirements for analysis of remedial alternatives. The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the analysis is based. The final two criteria, referred to as modifying criteria, are typically applied following the public comment period for the Proposed Plan to evaluate state and community acceptance. The following sections describe each criterion and the manner in which it is interpreted for the individual and comparative remedial alternatives analyses.

5.1.1 Threshold Criteria

5.1.1.1 Overall Protection of Human Health and the Environment

This criterion requires that each alternative adequately protect human health and the environment. It draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. These criteria are discussed below and in Section 5.1.2 "Primary Balancing Criteria."

5.1.1.2 Compliance with ARARs

Alternatives are assessed as to whether they attain federal and state ARARs, including:

- Location-specific ARARs (*e.g.*, requirements for construction in the coastal zone or wetlands).
- Action-specific ARARs (*e.g.*, requirements for transportation of hazardous waste).

No chemical-specific ARARs were found to be applicable to this remedial action. Refer to Section 2.3 "Development of ARARs" for a compilation and discussion of the ARARs.

None of the identified action-specific or location-specific ARARs are applicable to the No Action alternative.

The six active alternatives were analyzed for compliance with ARARs by dividing each alternative into seven different elements or activities. These elements are described in the following list. Each bullet highlights some of the aspects of each element which will be applicable to the identified ARARs.

- Pre-construction Activities: This element involves the collecting, processing, and analyzing of numerous sediment cores for chemical and geotechnical properties. This element also includes the decontamination of equipment and the disposal of contaminated investigation derived waste (IDW).

- Construction and Operation of a Support Area: The site is assumed to be near the river and includes a dock and boat launch, and possibly some structures for housing equipment and supplies. These facilities could be portable rented units, or could involve the construction of permanent new facilities.
- Dredging: Each of the active alternatives being considered includes some degree of sediment removal. This element includes the installation of sheet piling for protection of bulkheads, bridges, docks, and utilities. Dewatering of the dredged material and the resuspension of sediment material will also result from this activity.
- Capping: This element includes the placement of engineered caps, backfilling, armoring, and mudflat reconstruction in some areas of the river.
- CDF Construction and Operation: This element includes the installation of sheet piling, potential deep excavation of the disposal area, and transportation and offloading of dredged sediments into the CDF via mechanical or hydraulic means. This element also includes activities for closing the CDF once the project is completed.
- Thermal Treatment: This element includes the construction of an on-site thermal treatment plant, transportation of sediments from the CDF to the treatment works, and activities involved with the permanent treatment of the contaminated sediment such as control of air emissions resulting from the process.
- Wastewater Treatment and Discharge: Options for this element are treatment and discharge of wastewater; pretreatment of wastewater and discharge to a POTW or to the river; or discharge to a POTW without pretreatment. This element includes the construction and operation of an on-site treatment facility or the acquisition of a package treatment facility, if needed.

Table 5-2 lists the ARARs and their statutory or regulatory citations for each of the seven remediation elements described above. This table also presents the rationale for the parts of each element of the remediation process that will fall under each ARAR.

Each ARAR will be considered in detail during the design phase to provide for compliance during construction and remediation.

5.1.2 Primary Balancing Criteria

5.1.2.1 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. Factors that should be considered, according to the NCP and RI/FS guidance (USEPA, 1988) are as follows:

- Magnitude of residual risks in terms of amounts and concentrations of contaminated sediment remaining following the implementation of a remedial action.
- Long-term reliability and adequacy of the engineering and institutional controls, including uncertainties pertaining to land disposal of contaminated sediment and residuals.

The approach for assessing each of these factors is summarized below. For the purposes of this evaluation, it is assumed for each active alternative that the long-term period begins after remedial actions are completed in 2018.

<u>Magnitude of Residual Risk:</u> To evaluate the magnitude of residual risk present following remediation of the Area of Focus, the calculations provided in Section 8 of Appendix C "Risk Assessment" were performed. The risk calculations rely on the predictions of future sediment surface concentrations presented in Appendix D "Empirical Mass Balance Model." These predictions assume that active remediation would be capable of generating a surface with concentrations at or below recontamination levels, regardless of whether capping or dredging (with subsequent backfill or capping) is implemented. Once active remediation of the surface sediments of the Area of Focus has been completed, recontamination of the remediated surface would occur due to deposition of contaminated sediment originating from contributing sources outside of the

Area of Focus, while ongoing natural recovery processes would serve to reduce the degree of contamination associated with these deposited solids.

The contributing sources of contaminated sediment include freshwater flow over Dundee Dam, erosional areas located below the dam (outside of the Area of Focus), CSO/SWOs, and tidal exchange with Newark Bay. All of these sources are assumed to follow the observed rates of decline described in Appendix D "Empirical Mass Balance Model." There may be other inputs to the system but, based on the mass balance findings, such inputs could contribute only minimally to future sediment concentrations, and thus to post-remediation risk.

The recontamination processes modeled in Appendix D "Empirical Mass Balance Model" are dependent on the deposition rate in the Area of Focus after remedial actions are complete. The model relies on deposition rates ascertained from bathymetric surveys conducted between 1989 and 2004 and estimates of exchange of solids between the Area of Focus and each of the contributing sources. Deepening of the river in the Area of Focus would likely increase the overall deposition rate in that area, and would also affect the exchange between each of the contributing sources of solids loads and the Area of Focus to some degree.

The engineered cap that would be placed in areas where significant inventory is to be sequestered would be designed to withstand the erosive forces predicted by modeling in those areas (see Appendix G "Cap Erosion and Flood Modeling"). Regular maintenance would be required to sustain adequate coverage over the long term (possibly in perpetuity), thereby reducing the likelihood of release. Backfill would only be placed in those areas where all inventory has been targeted and only a minimal thickness of contaminated fine-grained sediment due to dredging residuals remains after removal activities are completed, and therefore any erosion of this backfill layer would result in minimal potential for release. It should be noted that backfill layers would not be monitored or maintained.

The likelihood that contamination would be released from the CDF is considered minimal. Significant industry experience associated with construction and maintenance of CDFs exists, and the design and construction of a CDF would be conducted so as to reduce the potential for future exposure. Excavation that may occur within the footprint of the CDF to increase its capacity would need to be accomplished in low permeability geologic strata or effectively lined with similar material.

<u>Adequacy and Reliability of Controls:</u> The adequacy and reliability of controls associated with each alternative has been assessed by examination of the individual process options employed.

Engineered caps, which include an armor layer in erosive areas, have been shown to be adequate in achieving sequestration of contaminated sediment. The erosive areas which are assumed for conceptual design purposes to require armor were determined using the results of the hydrodynamic modeling presented in Appendix G "Cap Erosion and Flooding Modeling." The reliability of engineered caps depends upon proper design and the consistency and sufficiency of future maintenance.

Placement of backfill material, which would not include armor and would not be monitored or maintained, is not considered to be adequate or reliable in maintaining sequestration. Since backfill would only be placed in those areas where minimal amounts of contaminated fine-grained sediments remain after removal activities are complete, any erosion would be of significantly diluted sediments.

Based on the evaluations presented in Section 4.2 "Selection of Representative Process Options," thermal treatment is a representative *ex situ* treatment process option selected for detailed analysis. Thermal treatment has been shown to be effective in achieving destruction and removal efficiencies of 99.9999 percent for organic contaminants. Volatile metals can be effectively removed from flue gas with properly designed controls, typically using activated carbon. Non-volatile metals are either sequestered in glass (for vitrification) or in the slag or ash produced during thermal destruction. Therefore, thermal treatment is considered an adequate treatment technology.

Off-gas and particulate emissions from thermal treatment facilities are effectively controlled to meet applicable standards by scrubbers and other pollution control devices. Residuals from thermal treatment would be disposed in a secure landfill or CDF. Any beneficial use product created by the thermal treatment process would be tested to verify that it does not pose a risk to end users.

The use of a CDF for storage or final disposal, if constructed properly (*e.g.*, with low permeability barriers and effluent controls) is considered to be both adequate and reliable based on the preliminary identification of potential sites and the use of similar facilities in other projects. Design and construction of a CDF would be conducted in accordance with USEPA guidance, including an assessment of contaminant migration pathways (USEPA, 2005).

Long-term maintenance procedures would be required to ensure the reliability of the remedy. An engineered cap would require inspection of the cap by bathymetric surveys and maintenance of the cap by placement of additional material on a routine basis in perpetuity. For the purposes of conceptual design an annual basis has been assumed, but an increase in frequency after major storms could be considered, or conversely a decrease in frequency after determining that the cap is suitably stable. In addition, long-term institutional controls, as discussed in Section 4.2 "Selection of Representative Process Options," may be required to maintain the integrity of capped or backfilled areas. Five-year reviews would be incorporated to evaluate whether the remedy continues to be adequate and reliable.

5.1.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. The evaluation focuses on the following factors:

- Treatment processes the remedy will employ and the materials they will treat.
- The mass and volume of hazardous materials that will be treated.
- The degree of expected reduction in toxicity, mobility, or volume.
- The degree to which treatment will be irreversible.
- The type and quantity of treatment residuals that will remain following treatment.
- Whether the alternative would satisfy the statutory preference for treatment as a principal element.

This criterion is evaluated both by the extent to which toxicity, mobility, and volume of contaminated sediments are reduced within the Lower Passaic River, as well as the extent to which toxicity, mobility, and volume of sediments are reduced based on the final treatment or disposition of removed sediments.

The degree of volume reduction of the contaminated sediment varies based on the depth and extent of dredging. The type of treatment specified for the dredged material dictates the degree of reductions in toxicity, mobility, and volume. Thermal treatment would be expected to achieve approximately 99.9999 percent reduction in organic contaminants. Residuals from thermal treatment would be disposed in a secure landfill or CDF. Thermal treatment would meet the statutory preference for treatment.

If dewatering and wastewater treatment were implemented, these processes would reduce the toxicity, mobility, and volume of contaminants in process water, but would likely generate treatment residuals such as flocculation sludge and filter sands. The quantities of these treatment residuals would depend on the sediment volumes that are removed.

Storage or disposal of dredged material in a CDF would reduce the mobility of contaminated material, and some volume reduction of the solid matrix (but not the contaminants themselves) is possible with time, through consolidation of the placed dredged material. However, this approach would not reduce the toxicity of the dredged material, and would not meet the statutory preference for treatment.

For capping, the mobility of contaminants in capped areas would be reduced because the solids-bound contaminants would be sequestered under an engineered cap, thus reducing the transport to Newark Bay and the New York-New Jersey Harbor Estuary. Nevertheless, capping does not satisfy the CERCLA statutory preference for treatment. There is no reduction in the toxicity or volume of the contaminants under the cap.

5.1.2.3 Short-Term Effectiveness

The short-term effectiveness criterion addresses the impacts of the remedial alternatives during construction and implementation. The following factors are considered with respect to this criterion:

- Protection of the community during remedial actions.
- Protection of workers during remedial actions.
- Environmental impacts.
- Time until remedial action objectives are achieved.

The approach for assessing each of these factors is summarized below.

Protection of the Community during Remedial Actions: Protection of the community depends on the duration of construction and the potential for exposure to contamination due to remedial activities. During construction, transfer facilities and treatment areas present potential short-term risks to the community due to air emissions and noise. Access to these areas would be restricted to authorized personnel, and an ambient air monitoring program could be implemented where required. Work areas in the river would be isolated (access-restricted) for safety reasons. In-river barge traffic associated with the remedies would be monitored and controlled to minimize adverse effects on commercial or recreational use of the river.

Capping operations may be less disruptive of local communities than dredging (USEPA, 2005), and would result in less potential for noise disturbances and air pollution than dredging operations. Since capping operations do not involve the same secondary processes as dredging (*i.e.*, dewatering, treatment, and/or transport or contaminated sediment), the potential for exposure of the community to dredged material is expected to be much lower than for dredging operations.

In the short term, risks to humans from consumption of fish and shellfish remain the same, and existing fish advisories would continue to be enforced.

<u>Protection of Workers during Remedial Actions:</u> The implementation of any remedial action would potentially expose workers to contaminated sediment, and the extent of exposure depends heavily on project duration. However, dredging of contaminated sediment would likely result in increased possibility of exposure via direct contact, ingestion, and inhalation of contaminants in sediments and surface water. Workers will be required to follow Occupational Safety and Health Administration (OSHA) regulations and project-specific health and safety plans.

<u>Environmental Impacts:</u> The primary environmental impacts due to dredging operations would include a temporary increase in suspended sediments concentrations, and therefore, potentially a temporary increase in fish and shellfish tissue contaminant concentrations. There will also be a temporary loss of habitat for aquatic and benthic organisms. The degree of impact is directly related to the area remediated and volume dredged. These impacts will be mitigated by the use of environmental dredging techniques and best management practices that minimize resuspension.

Backfilling will be implemented to mitigate impacts to aquatic and benthic organisms, and a biological monitoring program will be implemented to verify the attainment of objectives for aquatic and benthic life and habitat replacement.

Activities associated with capping and CDF construction would also result in a temporary loss of habitat for aquatic and benthic organisms. Environmental impacts during capping would be mitigated by using cap placement techniques that avoid resuspension to the extent practicable.

Time Until Remedial Action Objectives are Achieved: The time until RAOs are achieved depends on the duration of several project components, including pre-design investigation, design, mobilization, dredging, backfilling and/or capping, reconstruction, and demobilization. In addition, following implementation, an equilibration period followed by a period of natural recovery would likely be required to achieve RAOs.

The comprehensive 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve RAOs through a fate, transport, and bioaccumulation model that is currently in development and not available for the FFS.

5.1.2.4 Implementability

This criterion addresses the technical and administrative feasibility of implementing the remedial alternatives. Implementability is evaluated based on the following factors:

- Technical Feasibility.
- Degree of difficulty associated with construction and operating the technology.
  - Reliability of the technology.
  - Ease of undertaking additional remedial actions, if necessary.
  - Ability to monitor the effectiveness of the remedy.
- Administrative feasibility.
  - Coordination with other agencies.
  - Ability to obtain approvals from other agencies.
- Availability of services and materials.
  - Availability of necessary equipment and specialists.
  - Availability of adequate treatment, storage capacity, and disposal services.

- Availability of prospective technologies.
- Availability of services and materials, plus the potential for obtaining competitive bids.

The approach for assessing each of these factors in relation to the process options which comprise the remedial alternatives is summarized below.

<u>Technical Feasibility:</u> Sediment removal via mechanical dredges is a common and available technology. The technology was shown to be feasible during the Dredging and Decontamination Pilot Study (Thompson *et al.*, 2006) performed in the Lower Passaic River in December 2005. However, technical difficulties that may be associated with dredging operations include shoreline protection, utility protection, resuspension of sediment, and management of dredging residuals. It is anticipated that engineering controls and data could be used to address these issues.

Implementation of an active remedial action would require obtaining adequate land space to construct transfer and processing facilities. A processing location would require wharf facilities and sufficient acreage to accommodate the needs of the project. Preliminary siting studies conducted by NJDEP and summarized in Appendix H "Dredged Material Management Assessments" identify a sufficient number of potentially acceptable properties to assume that a siting process conducted during a design phase could select a viable site. It should be noted that other sediment remediation projects have successfully sited transfer and processing facilities despite similarly challenging environments.

The reliability of secondary processes associated with dredging (*e.g.*, sediment dewatering, transport, treatment, beneficial use, and/or disposal) could impact the technical feasibility of the remedy. For instance, operational problems with dewatering equipment (*e.g.*, clogging of filters) could slow dredging operations. The use of CDF capacity for disposal or storage could reduce the project's dependence on these secondary processes.

Capping of contaminated sediments is typically accomplished with commonly available or easily adapted equipment. Technical difficulties pertaining to capping operations include locating a suitable borrow source for cap material (refer to "Availability of Services and Materials" below), ensuring that the cap materials are applied in a manner that produces a continuous layer that achieves the desired cap thickness and erosion protection, and ensuring that additional flooding would not be caused due to changes in bathymetry or bottom roughness. Implementation of capping would increase the cost of future remedial dredging operations, but would not preclude their implementation.

Administrative Feasibility: Remedial actions would have to be performed in accordance with ARARs. Restrictions on remediation activities, if placed by trustee agencies (*e.g.*, fish windows), could result in longer project durations, or require additional equipment for schedule purposes. For purposes of this analysis, it has been assumed that dredging restrictions (fish windows) would be waived.

If the Lower Passaic River navigation channel were to be de-authorized or the authorized depth changed prior to cap placement, this de-authorization or change in authorized depth would require approval by an act of Congress with concurrence by the State of New Jersey. Cap placement would require long-term site access restrictions to ensure no disturbances of the cap by passing vessels, channel maintenance, or other potential disturbances.

Availability of Services and Materials: Dredging and capping are both well developed technologies, and procurement of adequate, reliable, and available technology should not present a significant challenge to implementability.

Initial efforts have identified several potential land-based borrow sources in New Jersey collectively capable of supplying suitable capping material; however, the capacity of individual sources has not been determined. Additionally, under the New York Harbor Deepening Program, several million cubic yards of sand will be removed from federal navigation channels between 2008 and 2011; although modeling results presented in

Appendix G "Cap Erosion and Flood Modeling" show that a cap cannot be constructed of this sand alone, this sand could be suitable for use in a filter layer or as backfill material. Furthermore, substantial quantities of rock will be removed from federal navigation channels, and could, if processed, be used as armor material. Significant cost savings would be realized if remediation activities could be coordinated with regional dredging programs (*e.g.*, utilization of sand or rock from the Harbor Deepening Program) to beneficially use this dredged material for backfill of dredged areas or construction of an engineered cap.

A preliminary review of the environs of the Lower Passaic River and Newark Bay suggests there are various nearshore areas amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any alternative. A thorough siting study would be required during the design phase to select an appropriate location.

Some portion of the contaminated sediment in the Lower Passaic River could be treated via thermal destruction methods. This feasibility analysis has identified potential thermal treatment options and vendors, and has identified no technical issues that would prevent construction of a new onsite facility.

5.1.2.5 Cost

Costs for CERCLA evaluations are divided into two principal categories: capital costs and annual O&M costs. Consistent with the RI/FS guidance (USEPA, 1988), cost estimates performed during the feasibility study stage are expected to provide an accuracy of -30 percent to + 50 percent. Capital costs and O&M costs have been estimated for all of the active remedial alternatives. Cost tables and a summary of major cost assumptions are provided in Appendix J "Cost Estimates."

Capital Costs: Capital cost items include activities pertaining to pre-construction investigations and design, mobilization/demobilization, site preparation, dredging and/or capping, and dredged material management. Unit prices for capital cost items were based on estimates from vendors and contractors, cost estimates from projects involving similar activities, and engineering judgment. In addition, an allowance for construction management of 7 percent of the capital costs, a fee of 10 percent of the capital costs, and a contingency allowance of 20 percent of the capital costs have been incorporated into the cost estimate.

O&M Costs: O&M costs for the active alternatives include activities such as bathymetric surveys, sediment and water column sampling, biota monitoring, and cap monitoring and maintenance. As for the capital costs, unit costs for O&M activities were based on estimates from vendors and contractors, cost estimates from projects involving similar activities, and engineering judgment. The cost estimates generated for this analysis are based on an O&M period of 30 years. However, a longer timeframe may apply for cap maintenance (*e.g.*, in perpetuity).

Present Worth Analysis: In order to compare costs for alternatives that have different implementation time frames, the present worth for each alternative was calculated. Costs are presented in 2006 dollars. A discount rate of 5 percent is used for the present worth calculation. The present worth of annual O&M activities was calculated for an assumed duration of 30 years.

5.1.3 Modifying Criteria

5.1.3.1 State Acceptance

This criterion provides the state – in this case, the State of New Jersey – with the opportunity to assess any technical or administrative issues and concerns regarding each of the alternatives. State acceptance is not addressed in this document, but will be addressed in the ROD. It is important to note that NJDOT is the WRDA non-federal sponsor and NJDEP is a Trustee for the Site; both are agency partners participating in the Study. As such, input from the State of New Jersey was sought and considered throughout the development of the FFS.

5.1.3.2 Community Acceptance

Issues and concerns the public may have regarding each of the alternatives fall into this criterion. As with state acceptance, this criterion will be addressed in the ROD once comments on the FFS and proposed plan have been received. Input from the public and interested stakeholders, including the Cooperating Parties, was sought and considered throughout development of the FFS. This occurred through various technical Workgroup sessions organized and hosted by USEPA, through publication of information on the project website www.ourpassaic.org, publication of information to interested members of the public in the form of ListServ notices, and other Community Involvement activities.

5.2 ANALYSIS OF ALTERNATIVES

The detailed analysis of the individual alternatives with respect to the criteria discussed above is presented in Table 5-1 (attached). This section presents a comparison among alternatives and analyzes trade-offs to be considered for each criterion.

5.2.1 Overall Protection of Human Health and the Environment

Based on the risk evaluations summarized in Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas" and presented in full in Appendix C "Risk Assessment," existing conditions present unacceptable risks to human health and the environment. Active remediation of the Area of Focus reduces the COPC and COPEC concentrations in the surface sediments to within the background concentrations that are currently introduced to the Lower Passaic River from the Upper Passaic River, reduces the human health risk by 95 to 98 percent (fish versus crab consumption), and reduces the ecological hazard by 78 to 98 percent (species dependent) (refer to Section 2.6 "Risk Reduction Resulting from Remediation of Identified Target Areas"), which meets the RAO. Based on prediction of future surface concentrations generated using the Empirical Mass Balance Model (Appendix D), active remediation of the Area of Focus followed by MNR will achieve any threshold for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by the No Action alternative. The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus (refer to Section 2.7 "Selection of Target Area for

Remediation"). For this reason, the six active alternatives are considered more protective of human health and the environment than the No Action alternative.

The 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve RAOs using a fate, transport, and bioaccumulation model that is currently in development and not available for the FFS.

5.2.2 Compliance with ARARs

None of the identified action-specific or location-specific ARARs are applicable to the No Action alternative. Each active alternative, if implemented, would be designed and constructed in compliance with the ARARs identified, except those which may be waived by the Regional Administrator in accordance with CERCLA Section 121(d).

The active alternatives are comprised of seven elements, as described in Section 5.1.1.2 "Compliance with ARARs." Table 5-2 lists the ARARs and their statutory or regulatory citations for each of these seven elements. This table also presents the rationale for the parts of each element of the remediation process that will fall under each ARAR.

5.2.3 Long Term Effectiveness and Permanence

5.2.3.1 Magnitude of Residual Risk

The overall risk reduction achieved by each alternative has been evaluated based on the future surface concentrations predicted by the Empirical Mass Balance Model (refer to Appendix D "Empirical Mass Balance Model"). Over the time frame considered (30 years after remedial actions are complete), the six alternatives which use active remedial measures reduce cancer risk for the combined child/adult receptor to 5×10^{-4} from fish consumption and to 4×10^{-4} from crab consumption. In addition, the non-cancer health HI for the adult receptor is reduced from 64 to 4.7 from fish consumption and from 86 to 3.5 from crab consumption (see Table 2-11). The non-cancer health HI for the child receptor is reduced from 99 to 22 from fish consumption and from 140 to 19 from crab consumption. The ecological hazards present at the site are reduced from 339 to 5.8 for the mink receptor and from 49 to 1.8 for the heron receptor. The risk reduction for each of the six active alternatives is equivalent at the level of precision achieved by the calculations presented in Appendix D "Empirical Mass Balance Model," and no additional risk reduction is estimated to result from additional removal of contaminated sediment, as each alternative places a sand layer and achieves equivalent surface concentrations following active remediation. In addition, all of the active remedial alternatives rely on institutional controls to maintain protectiveness following remedy construction, while natural recovery processes continue to reduce surface concentrations in the Area of Focus to reduce risks to within the risk range. Also, separate source control actions above Dundee Dam, when implemented, will accelerate the time frame within which the active alternatives achieve risk ranges.

The No Action alternative does not achieve the reductions in risk described above for the active alternatives. Over the time frame considered (30 years after the active components of remedial alternatives are complete), the natural recovery processes in the No Action alternative only reduce cancer risk for the combined child/adult receptor to 4×10^{-3} from fish consumption and to 3×10^{-3} from crab consumption; these levels are still well outside EPA's acceptable risk range. In addition, the non-cancer health HI for the adult receptor is reduced from 64 to 6.8 from fish consumption and from 86 to 5.2 from crab consumption. The non-cancer health HI for the child receptor is only reduced from 99 to 31 from fish consumption and from 140 to 27 from crab consumption. The ecological hazards present at the site are reduced from 339 to 52.4 for the mink receptor and from 49 to 5.2 for the heron receptor. These reductions are less than for the active alternatives It should be noted that the risk reduction observed from the No Action alternative is due to natural recovery processes, among which a dominant mechanism is likely the dilution of contaminated sediments in the Area of Focus due to exchange with other contributing sources of solids load. This dilution likely results in transfer of contaminated sediments from the Area of Focus to Newark Bay and the New York-New Jersey Harbor Estuary.

5.2.3.2 Adequacy and Reliability of Controls

The No Action alternative does not provide for engineering controls on the river sediments. Among the active alternatives, there is not a great difference in the degree of adequacy of controls achieved. The reliability of both dredging and engineered caps depends upon proper design and implementation, while the reliability of capping also depends on the consistency and sufficiency of future maintenance.

Alternative 1 relies exclusively on placement of a backfill layer to provide a measure of control in the event that residual contamination poses health risks. This alternative does not include an engineered cap, because the intent is for the contaminated fine-grained sediment to be removed with the assumption that the underlying less-contaminated sand material will not erode to any significant extent. The backfill layer is not intended to be maintained, in contrast to the engineered cap in Alternative 2 whose thickness is maintained in the long term in order to ensure protectiveness of contaminant inventory left underneath.

Alternatives 3, 4, 5, and 6 rely on varying combinations of backfill and engineered cap, depending on the amount of contaminated inventory left after dredging. Of these four alternatives, Alternative 3 proposes removing the most fine-grained sediment down to the underlying sandy layer, while Alternative 4 proposes leaving behind the most contaminant inventory, so that Alternative 3 relies most heavily on backfill and Alternative 4 relies most on engineered capping. Institutional controls would be required to ensure that engineered cap layers are not disturbed by human activities.

In all active alternatives, the use of a CDF for storage or final disposal, if constructed properly (*e.g.*, with low permeability barriers and with effluent controls) is considered to be adequate and reliable based on the preliminary identification of potential sites and the use of similar facilities in other projects.

Established thermal destruction facilities have sufficient prior experience with treatment of hazardous materials and disposal of treatment residuals to predict a high level of reliability. Newly constructed facilities would require a prove-out period to demonstrate ability to reduce contaminant concentrations resulting from implementation of any active alternative to acceptable levels reliably and to ensure air emissions are within acceptable ranges.

5.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

5.2.4.1 Treatment Processes Used and Materials Treated

The No Action alternative does not involve any containment or removal of contaminants from the Lower Passaic River sediments. Among the active alternatives (Alternatives 1-6), the treatment processes used do not vary.

The extent to which each treatment process is used varies based on the mass and volume of sediment removal. For example, Alternative 2 removes the least amount of sediment, while Alternative 1 removes the most. After removal, thermal treatment of dredged sediment, if used, will irreversibly destroy organic contaminants in the treated sediment, while non-volatile metals will be fused and bound into the residual matrix. Volatile metals will be released from the sediment matrix and captured during control of the off-gas emissions. In addition, water treatment process associated with dewatering operations will reduce the toxicity, mobility, and volume of contaminants present in process water.

5.2.4.2 Amount of Hazardous Material Destroyed or Treated

The No Action alternative does not involve any destruction or treatment of contaminants from the Lower Passaic River sediments. Among the active alternatives, the amount of contaminated sediment removed and treated varies based on the depth and extent of dredging. The estimates of removal volume are presented in Table 5-1.

5.2.4.3 Degree of Expected Reductions in Toxicity, Mobility, and Volume

The No Action alternative results in minimal reduction in toxicity, mobility, and volume by natural recovery processes. It should be noted that any reductions observed from the

No Action alternative is due to natural recovery processes, among which a dominant mechanism is likely the dilution of contaminated sediments in the Area of Focus due to exchange with other contributing sources of solids load. This dilution likely results in transfer of contaminated sediments from the Area of Focus to Newark Bay and the New York-New Jersey Harbor Estuary.

The six active alternatives vary slightly in their expected degrees of reduction.

Alternative 1 involves removal of all fine-grained sediment. Alternatives 2-6 involve some removal of sediments before placement of a cap and armor. Each of these alternatives would, to some degree, reduce the volume of contaminated sediment in the Lower Passaic River by removal and subsequent treatment, if dredged material management Scenario B were selected. The degree of volume reduction varies based on the depth and extent of dredging. The type of treatment specified for the removed sediment dictates the degree of reductions in toxicity, mobility, and volume. Thermal treatment would be expected to achieve approximately 99.9999 percent reduction in organic contaminants. Thermal treatment residuals could be disposed in a secure landfill or CDF. Material disposed in a CDF would not be treated prior to placement, but the mobility of contaminants in the material would be reduced. Disposal in a CDF would not satisfy the CERCLA statutory preference for treatment.

Alternatives 2-6 rely on capping to sequester contaminated sediments. The cap reduces the mobility of contaminants, thus reducing the transport to Newark Bay and the New York-New Jersey Harbor Estuary. Capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the contaminants under the cap.

5.2.4.4 Type and Quantity of Residuals Remaining after Treatment

The No Action alternative generates no residuals. The active alternatives vary in the quantity of residuals generated based on the degree of sediment removal.

If sediment removal is followed by dewatering and water treatment, residuals such as flocculation sludge and filter sands would be generated. The quantities of these residuals would depend upon the sediment volumes that are removed. In addition, alternatives involving sediment dewatering may generate debris such as rocks, wood, and a variety of navigational and urban refuse that would be unable to pass through the dewatering treatment train; these materials would need to be managed as waste or recycled.

Thermal destruction would irreversibly destroy contaminants in the treated sediment. Thermal treatment residuals could be disposed in a secure landfill or CDF or be used beneficially as a product.

5.2.5 Short Term Effectiveness

No construction activities are associated with the remediation of sediments for the No Action alternative, so it does not increase the potential for direct contact or ingestion of contaminants from the sediments beyond current levels. The active alternatives vary slightly in short term effectiveness, as discussed below.

5.2.5.1 Protection of the Community during Remedial Actions

Implementation of any active remediation alternative would result in impacts to the community (*e.g.,* noise, lights, and traffic) and could potentially require the processing, storage, transportation, and disposal of contaminated sediment near the Lower Passaic River. Engineering controls would be in place to reduce the potential for exposure of the community to contaminants.

The placement of cap materials would likely result in a lesser degree of resuspension than dredging of contaminated sediment (USEPA, 2005). The overall duration during which the community would be impacted is greater for alternatives which remove a greater volume of material (*e.g.,* Alternative 1 would impact the community for a longer period of time than Alternative 2).

5.2.5.2 Protection of Workers during Remedial Action

The implementation of any active remediation alternative would potentially expose workers to contaminated sediment; however, dredging activities could result in a higher likelihood of exposure via direct contact, ingestion, and inhalation of contaminants in sediments and surface water than would placement of capping materials. The overall time during which workers would require protection is greater for alternatives which remove a greater volume of material.

5.2.5.3 Environmental Impacts

Alternatives which involve dredging of larger quantities of material require longer project durations, and potentially present incrementally greater potential for increased exposure of the community to dredged material. This potential for exposure can be reduced with the proper engineering controls, health and safety approaches, and design considerations.

In addition, the short term environmental impacts associated with resuspension of contaminated sediment would likely be incrementally greater for alternatives involving greater volumes of removal.

The existing habitat present in the Area of Focus would be impacted by any active remediation alternative. In addition, resuspension associated with cap placement or dredging activities could result in the transport of contaminated sediments and subsequent impact to adjacent areas. The placement of cap materials would likely result in a lesser degree of contaminant resuspension than dredging of contaminated sediment.

All active alternatives would involve the placement of clean material over existing sediment and reconstruction of mudflat areas impacted by remedial activities. In areas where armor is placed, benthic recolonization could occur, provided that silt or other benthic habitat material is subsequently deposited via natural processes. The construction of a CDF would constitute a permanent impact to habitat, and would require mitigation.

5.2.5.4 Time until Remedial Action Objectives are Achieved

The six active alternatives vary slightly in duration of implementation, as each alternative contains similar components including pre-design activities, design, mobilization, dredging, capping or backfilling, and demobilization. Following implementation, trends in surface sediment concentrations for each alternative are also comparable, as the post-implementation surface sediment concentrations achieved by each alternative are equivalent. These trends may be influenced by the depositional conditions achieved by each alternative, as discussed in Section 5.1.2.1 "Long-Term Effectiveness and Permanence."

The 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve RAOs through a fate, transport, and bioaccumulation model that is currently in development and not available for the FFS.

5.2.6 Implementability

5.2.6.1 Technical Feasibility

The No Action alternative and Alternatives 1-6 are all technically feasible. However, a major consideration in evaluating the feasibility of each alternative after implementation is the impact on flooding caused by changes in the bathymetry and bottom roughness of the river. The No Action alternative would likely result in a gradual increase in flooding impacts due to continued accumulation of sediments; however this has not been confirmed by modeling. Hydrodynamic modeling results presented in Appendix G "Cap Erosion and Flood Modeling" indicate that Alternatives 2 and 4 have considerable flooding impacts; implementation of either alternative would increase flooding by 93 and 24 acres respectively beyond the amount predicted by modeling of existing conditions. Conversely, implementation of Alternative 5 would result in a slight reduction (by 17 acres) in flooding impact compared to existing conditions. Alternatives 1, 3, and 6 were not modeled, but are expected to show reductions similar to or greater than those predicted by modeling of Alternative 5, as similar sediment surface conditions but greater water depths are achieved by implementation of these alternatives.

5.2.6.2 Availability of Services and Materials

Each active alternative utilizes both dredging and capping or backfilling. Dredging and capping are both well developed technologies, and adequate, reliable, and available technology can be procured; there are no anticipated challenges to implementability.

Initial efforts have identified several potential land-based borrow sources in New Jersey collectively capable of supplying suitable capping material for the implementation of active alternatives; however, the capacity of individual sources has not been determined. Additionally, under the New York Harbor Deepening Program, several million cubic yards of sand will be removed from federal navigation channels between 2008 and 2011; although modeling results presented in Appendix G "Cap Erosion and Flood Modeling" show that a cap cannot be constructed of this sand alone, this sand could be suitable for use in a filter layer or as backfill material. Furthermore, substantial quantities of rock will be removed from federal navigation channels, and could, if processed, be used as armor material. Significant cost savings would be realized if remediation activities could be coordinated with regional dredging programs (*e.g.*, utilization of sand or rock from the Harbor Deepening Program) to beneficially use this dredged material for backfill of dredged areas or construction of an engineered cap.

A preliminary review of the environs of the Lower Passaic River and Newark Bay suggests there are various nearshore areas amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any alternative. A thorough siting study would be required during the design phase.

Some portion of the contaminated sediment in the Lower Passaic River could be treated via thermal destruction methods. This feasibility analysis has identified potential thermal treatment options and vendors, and has identified no technical issues that would prevent construction of a new onsite facility.

5.2.6.3 Administrative Feasibility

The execution of any remedial activity in the Lower Passaic River would require significant coordination with and among federal, state, and local agencies. Alternatives 2-6, those involving capping, would require that issues pertaining to navigation be resolved prior to design of cap elevation, and that the creation of future habitat be discussed. Alternatives which incorporate greater quantities of dredging could potentially require incrementally more coordination due to the greater impact that dredged material management activities would have on the surrounding area and the need to identify suitable locations for a CDF for processing, storage, transportation, treatment, and disposal of dredged material.

5.2.7 Cost

The total cost for each alternative has been estimated based on capital costs as well as O&M costs, and is presented in Appendix J "Cost Estimates." The active alternatives range in cost from $0.9 billion to $2.3 billion.

5.2.7.1 Capital Costs

Capital costs have been estimated for activities pertaining to pre-construction investigations and design, mobilization/demobilization, site preparation, dredging and/or capping, and dredged material management. While capital costs for these activities vary predictably based on the extent of remediation conducted, the major drivers of capital cost are dredging and dredged material management. Alternatives which utilize dredging to remove a given volume of contaminated sediment are significantly more costly than alternatives which sequester the same volume of contaminated sediment by means of an engineered cap.

5.2.7.2 Operations and Maintenance Costs

Alternatives which employ an engineered cap over a greater area require more significant operations and maintenance costs. Monitoring of cap thickness and replenishment could be required, to some extent, in perpetuity. The extent of monitoring and maintenance, and therefore the total present worth of O&M costs, would depend on the time needed to verify the long term stability of the cap and the absence of significant contaminant fluxes through the cap. The cost estimates generated during this feasibility analysis have been based on a maintenance period of thirty years; however, a longer timeframe may apply for cap maintenance.

Finally, while operations and maintenance costs are higher for alternatives which utilize an engineered cap, the capital costs associated with dredged material management drive the total cost of alternatives which involve greater quantities of dredging. Alternatives involving capping achieve the same mass remediation and risk reduction as alternatives involving greater quantities of dredging for significantly lower total cost; however, the reliability of capping depends on the consistency and sufficiency of future maintenance activities.

6.0 ACRONYMS

° F	Degrees Fahrenheit
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
AhR	Aryl Hydrocarbon Receptor
Alt.	Alternative
ARARs	Applicable or Relevant and Appropriate Requirements
ARCS	Assessment and Remediation of Contaminated Sediments
BAF	Bioaccumulation Factor
CAD	Contained Aquatic Disposal
CASRN	Chemical Abstracts Service Registry Number
CBR	Critical Body Residues
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	Contaminant of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
CPT	Cone Penetrometer Testing
CRREL	Cold Regions Research and Engineering Laboratory
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CWA	Clean Water Act
D_{50}	Median Stone Size

DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DDx	Sum of DDD, DDE, and DDT isomers
D/F	Dioxins/Furans
DOER	Dredging Operations and Environmental Research
DQO	Data Quality Objective
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FFS	Focused Feasibility Study
FRTR	Federal Remediation Technologies Roundtable
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPAH	High Molecular Weight PAH
HSWA	Hazardous and Solid Waste Amendments
H:V	Horizontal:Vertical
IDW	Investigation Derived Waste
LDR	Land Disposal Regulation
LOAEL	Lowest Observed Adverse Effect Level
LPAH	Low Molecular Weight PAH
mg/kg	milligrams per kilogram of sediment
MLW	Mean Low Water

MNR	Monitored Natural Recovery
MPA	Mass Per Unit Area
NBSA	Newark Bay Study Area
NCP	National Contingency Plan
ND	Not Determined
ng/g	nanograms per gram of sediment
ng/kg	nanograms per kilogram of sediment
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJDOT-OMR	New Jersey Department of Transportation, Office of Maritime Resources
NJPDES	New Jersey Pollutant Discharge Elimination System
N.J.S.A.	New Jersey Statutes Annotated
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Levels
O&M	Operations and Maintenance
OENJ	Orion of Elizabeth New Jersey
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PaDEP	Pennsylvania Department of Environmental Protection
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCDD/F	Polychlorinated Dioxins/Furans

POTW	Publicly Owned Treatment Works
ppt	parts per trillion
PRG	Preliminary Remedial Goal
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RME	Reasonably Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SPI	Sediment Profile Imaging
SWO	Stormwater Outfall
T_b	Thickness for Bioturbation
TBC	To Be Considered
T_c	Thickness for Consolidation
TCLP	Toxicity Characteristic Leaching Procedure
T_e	Thickness for Erosion
TEQ	Toxic Equivalency Quotient
T_i	Thickness for Chemical Isolation
T_s	Thickness for Settlement

TSCA	Toxic Substances and Control Act
UCL	Upper Confidence Limit
µg/kg	micrograms per kilogram of sediment
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Services
VOC	Volatile Organic Compound
WRDA	Water Resources Development Act

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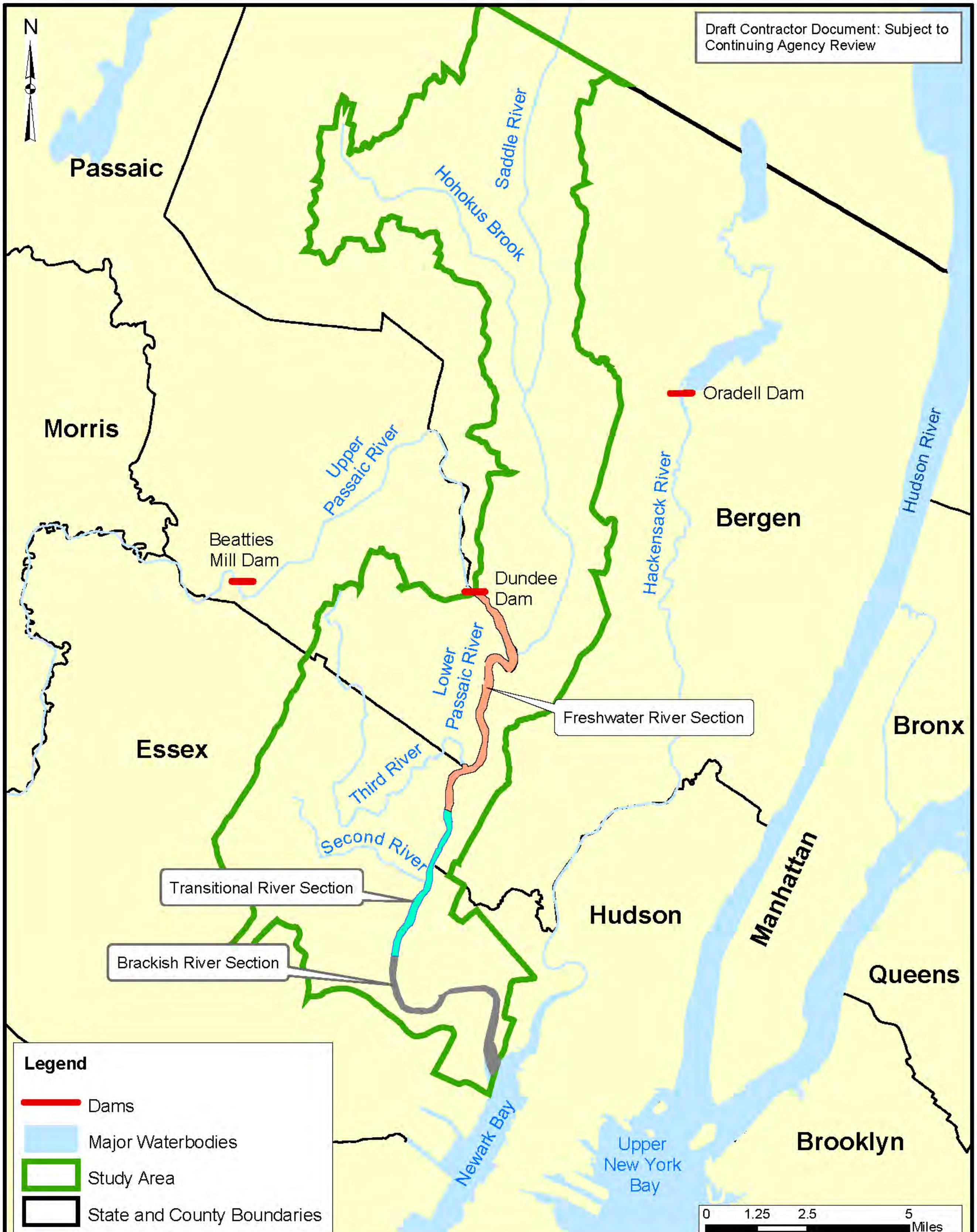
Figures



Study Area Location Map

Lower Passaic River Restoration Project

Figure 1-1

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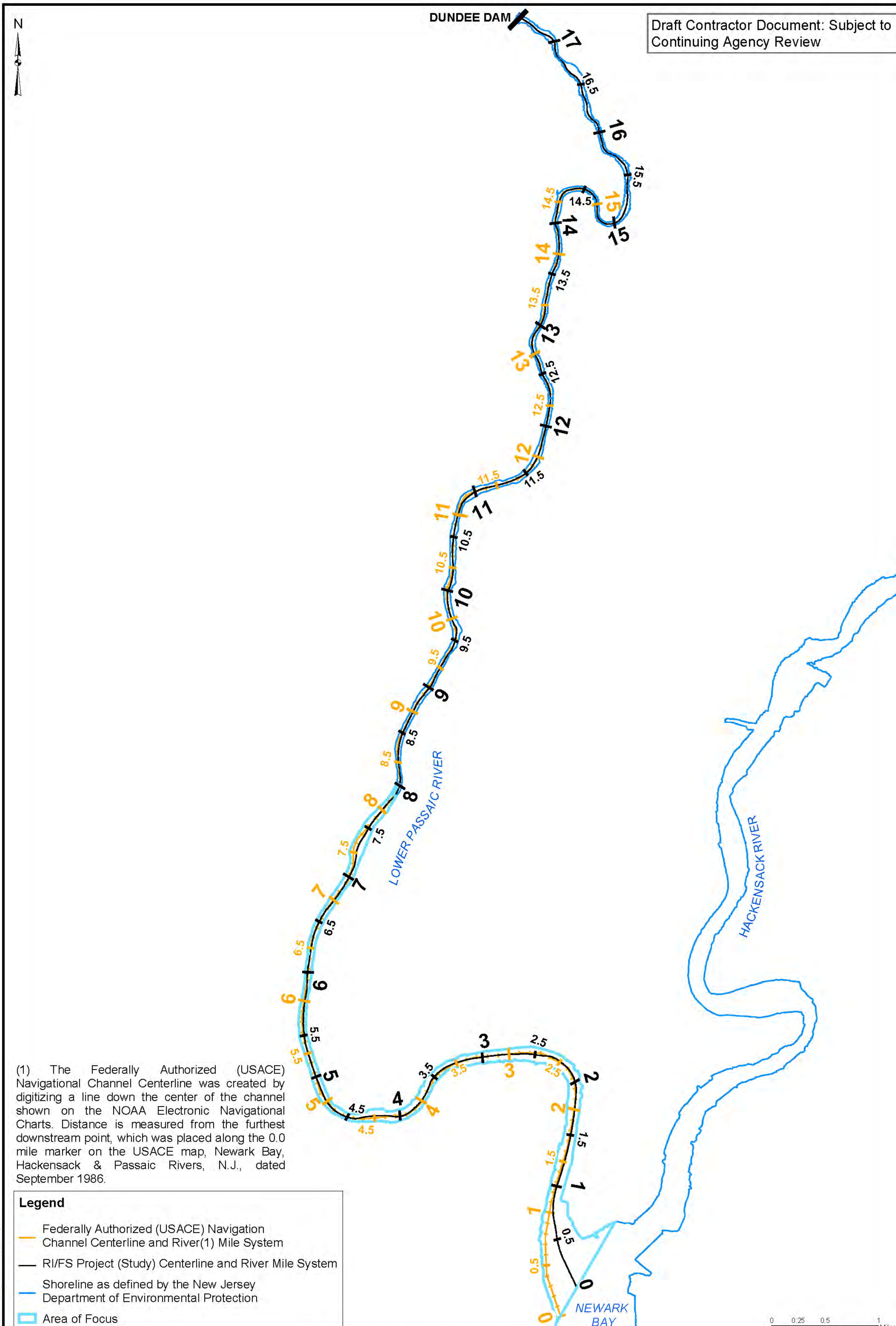

(1) The Federally Authorized (USACE) Navigational Channel Centerline was created by digitizing a line down the center of the channel shown on the NOAA Electronic Navigational Charts. Distance is measured from the furthest downstream point, which was placed along the 0.0 mile marker on the USACE map, Newark Bay, Hackensack & Passaic Rivers, N.J., dated September 1986.

Legend

- Federally Authorized (USACE) Navigation Channel Centerline and River(1) Mile System
- RI/FS Project (Study) Centerline and River Mile System
- Shoreline as defined by the New Jersey Department of Environmental Protection
- Area of Focus

Comparison of River Mile Systems

Lower Passaic River Restoration Project

FIGURE 1-2

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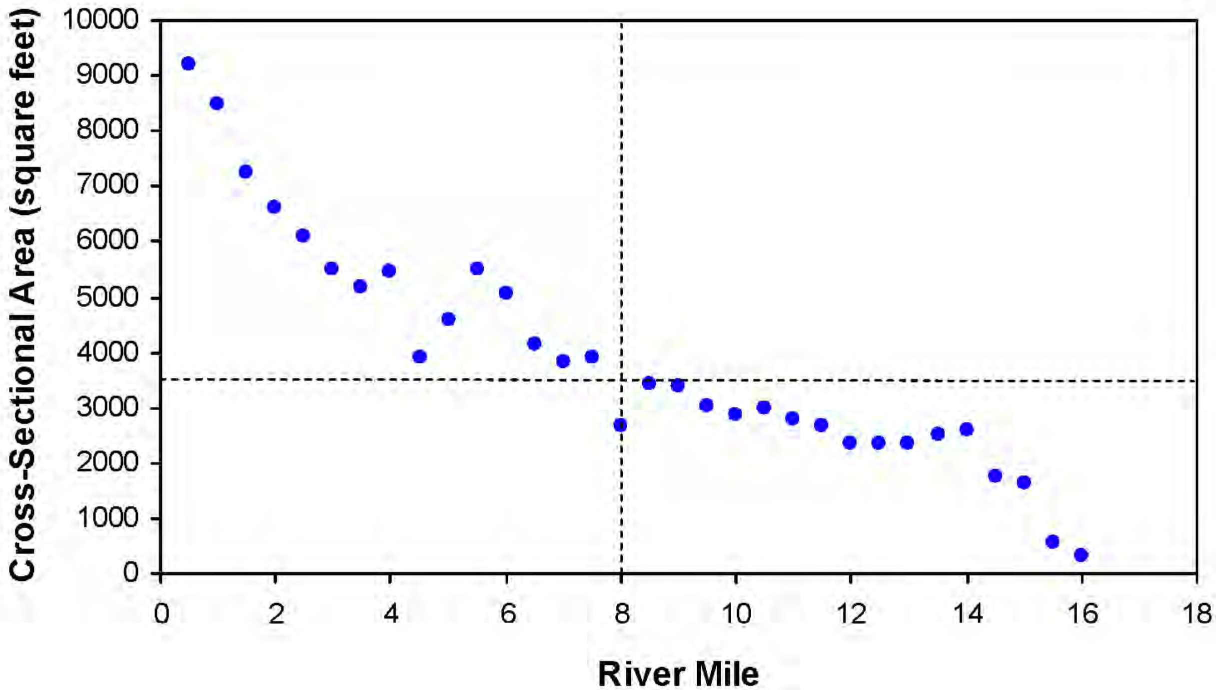

Legend

Cross-Sectional Area (square feet)

Highlights the change to a river cross sectional area of 3,500 square feet at RM8 (1)

Notes

Cross-sectional area estimated from 2004 bathymetric data surveyed by Rogers Survey, Inc. for USACE.

Cross-sectional area refers to the water filled area of the river channel when water level is equal to 0 feet elevation at NGVD29.

(1) RI/FS river mile system is used.

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Variation of Lower Passaic River Cross-Sectional Area with River Mile

Lower Passaic River Restoration Project

Figure 1-3

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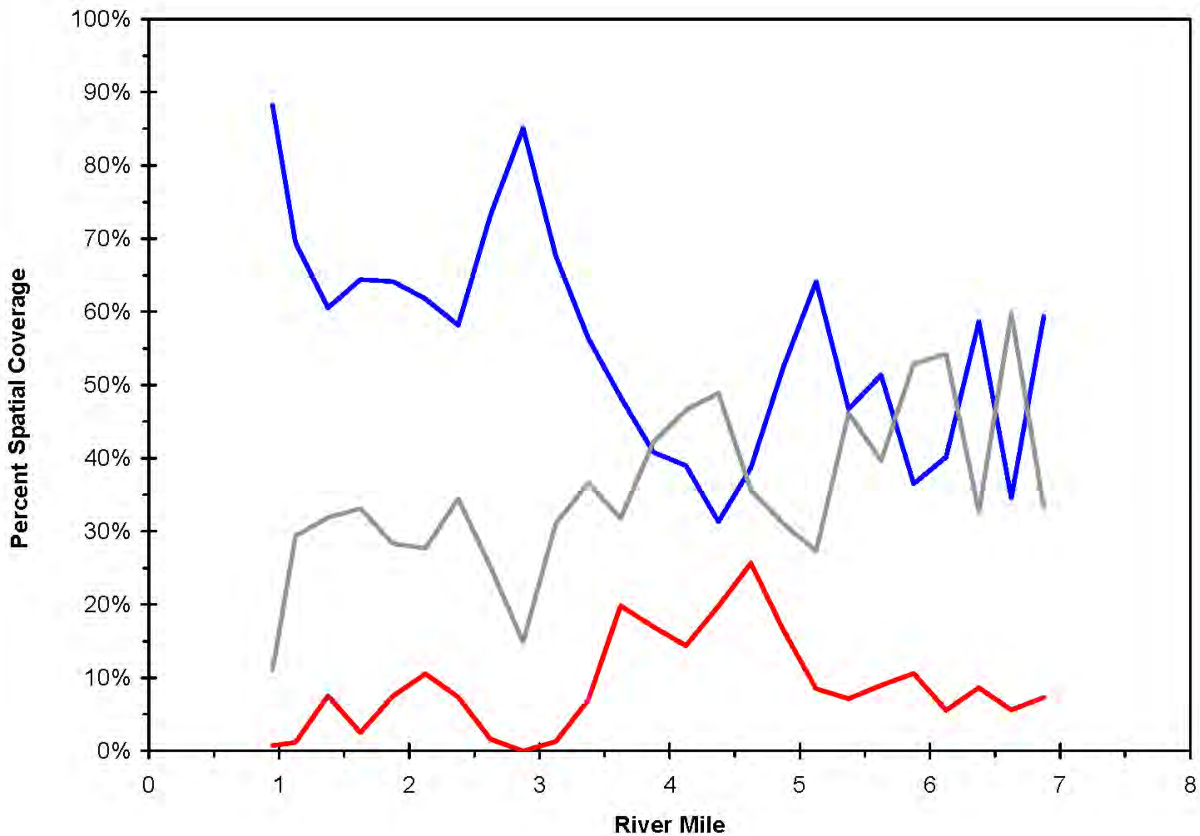

Legend

Consistently and Occasionally Erosional

Consistently and Occasionally Depositional

Bathymetrically Neutral Area

Notes

Refer to Appendix A "Conceptual Site Model" for more detail on net erosional, net depositional, and bathymetrically neutral areas.

RI/FS river mile system is used.

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US Army Corps of Engineers

Percent Spatial Coverage of Net Erosional, Net Depositional, and Bathymetrically Neutral Areas

Lower Passaic River Restoration Project

Figure 1-4

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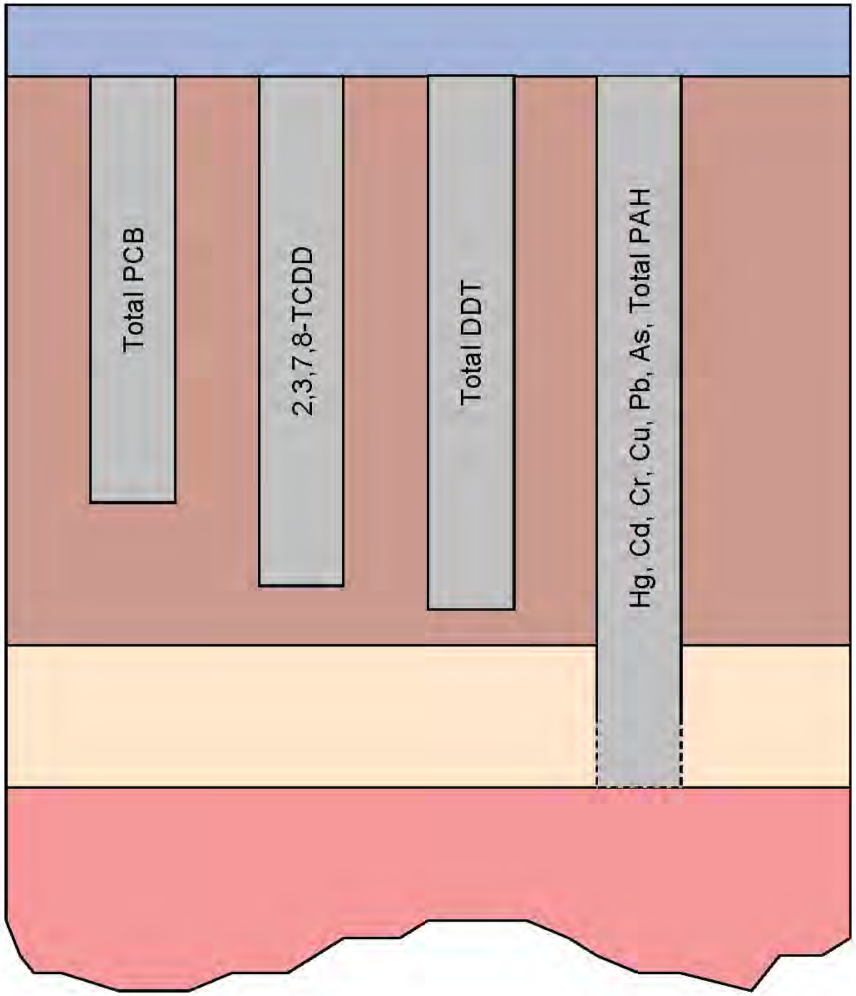

Legend

- Schematic of Sediment Core
- Water
- Fine-Grained Sediment
- Sand
- Clay

Notes

Hg = Mercury
Cd = Cadmium
Cr = Chromium
Pb = Lead
As = Arsenic

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Schematic of Nature and Extent of Contamination in Sediment Beds

Lower Passaic River Restoration Project

Figure 1-5

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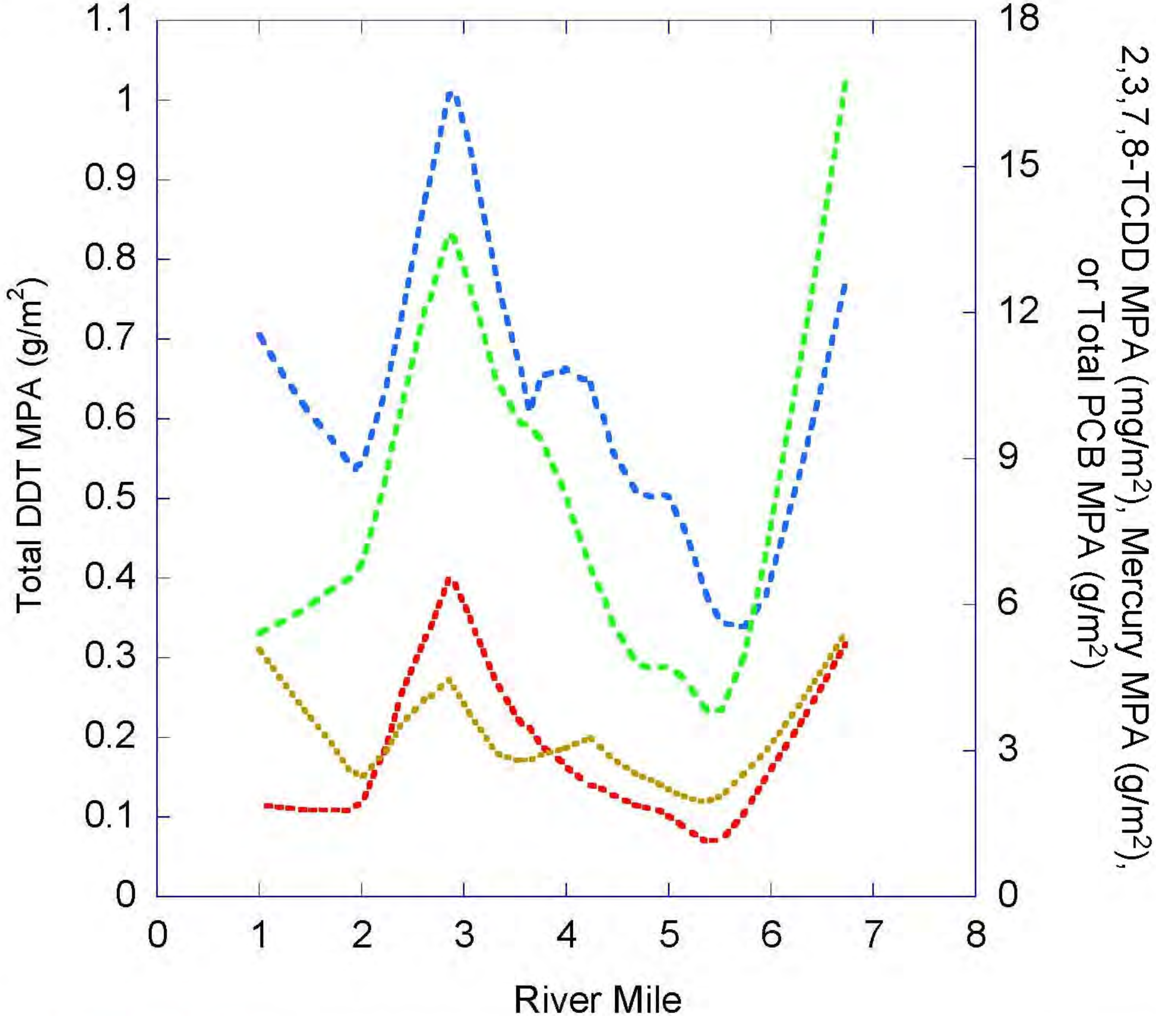

Legend

- Mercury MPA (g/m^2)
- 2, 3, 7, 8-TCDD MPA (mg/m^2)
- Total PCB MPA (g/m^2)
- Total DDT MPA (g/m^2)

Notes

MPA is mass per unit area.

RI/FS river mile system is used.

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Weighted Curve Sediment Inventory vs. River Mile

Lower Passaic River Restoration Project

Figure 1-6

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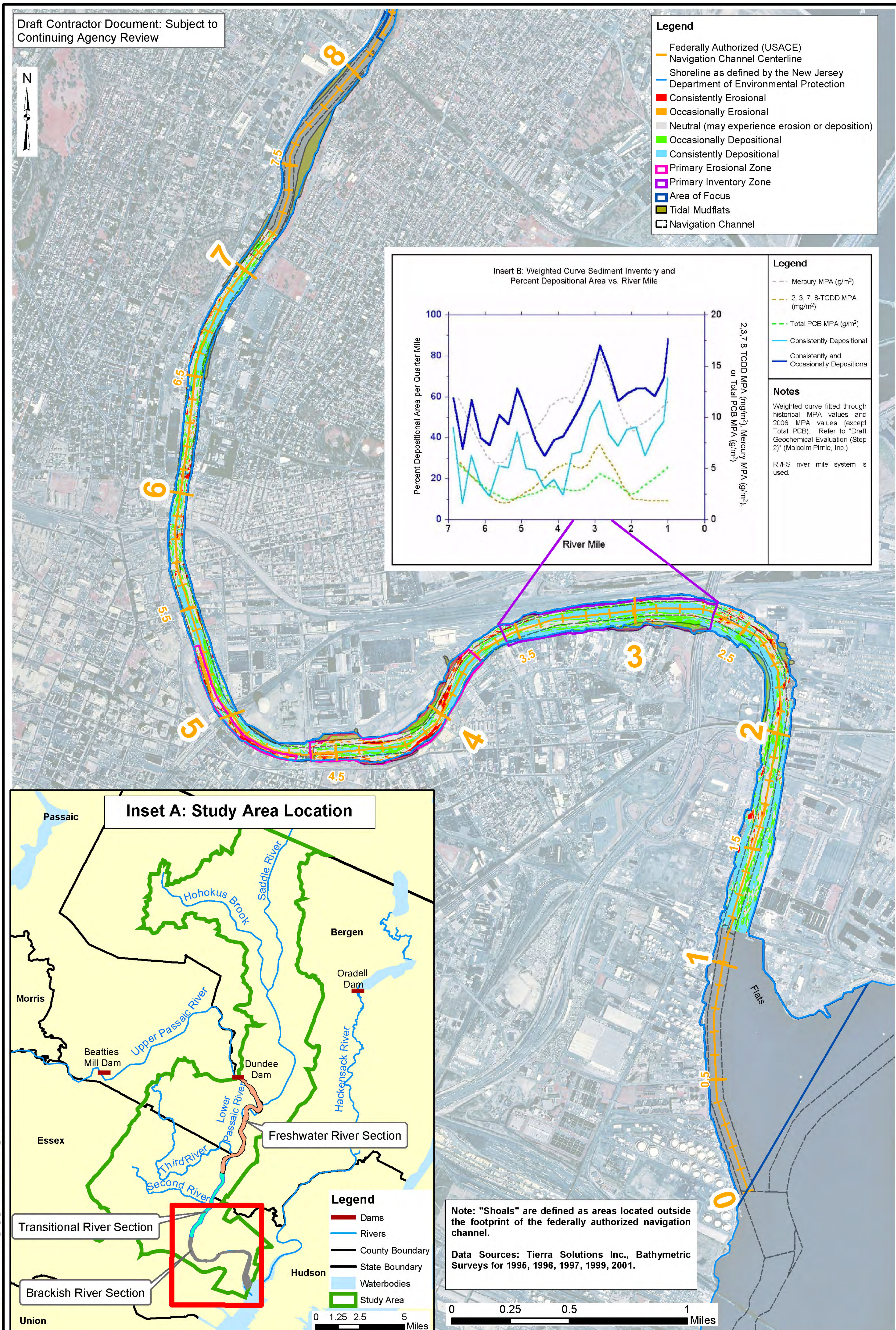
R2-0008902



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Potential Target Areas

Lower Passaic River Restoration Project

Figure 2-1

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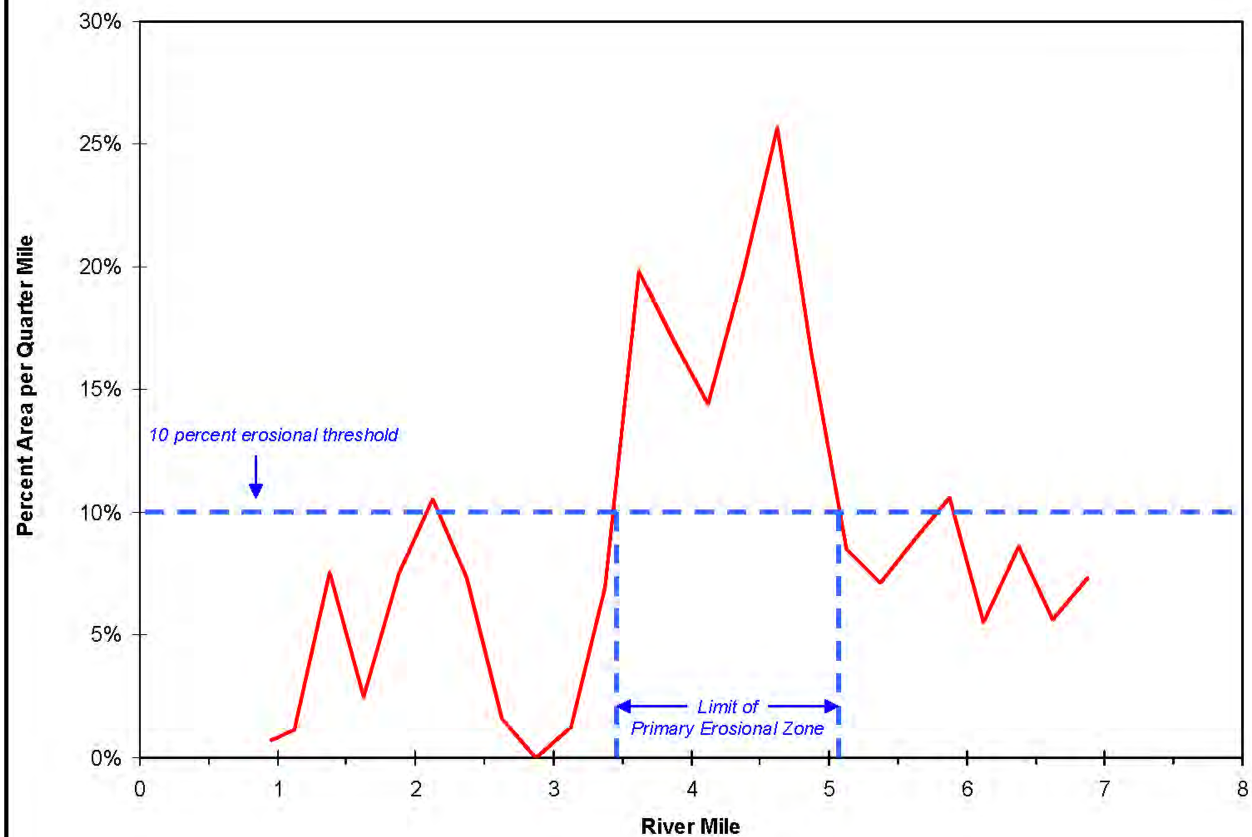

Legend

Consistently and Occasionally Erosional

Notes

RI/FS river mile system is used.

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Identification of Primary Erosional Zone

Lower Passaic River Restoration Project

Figure 2-2

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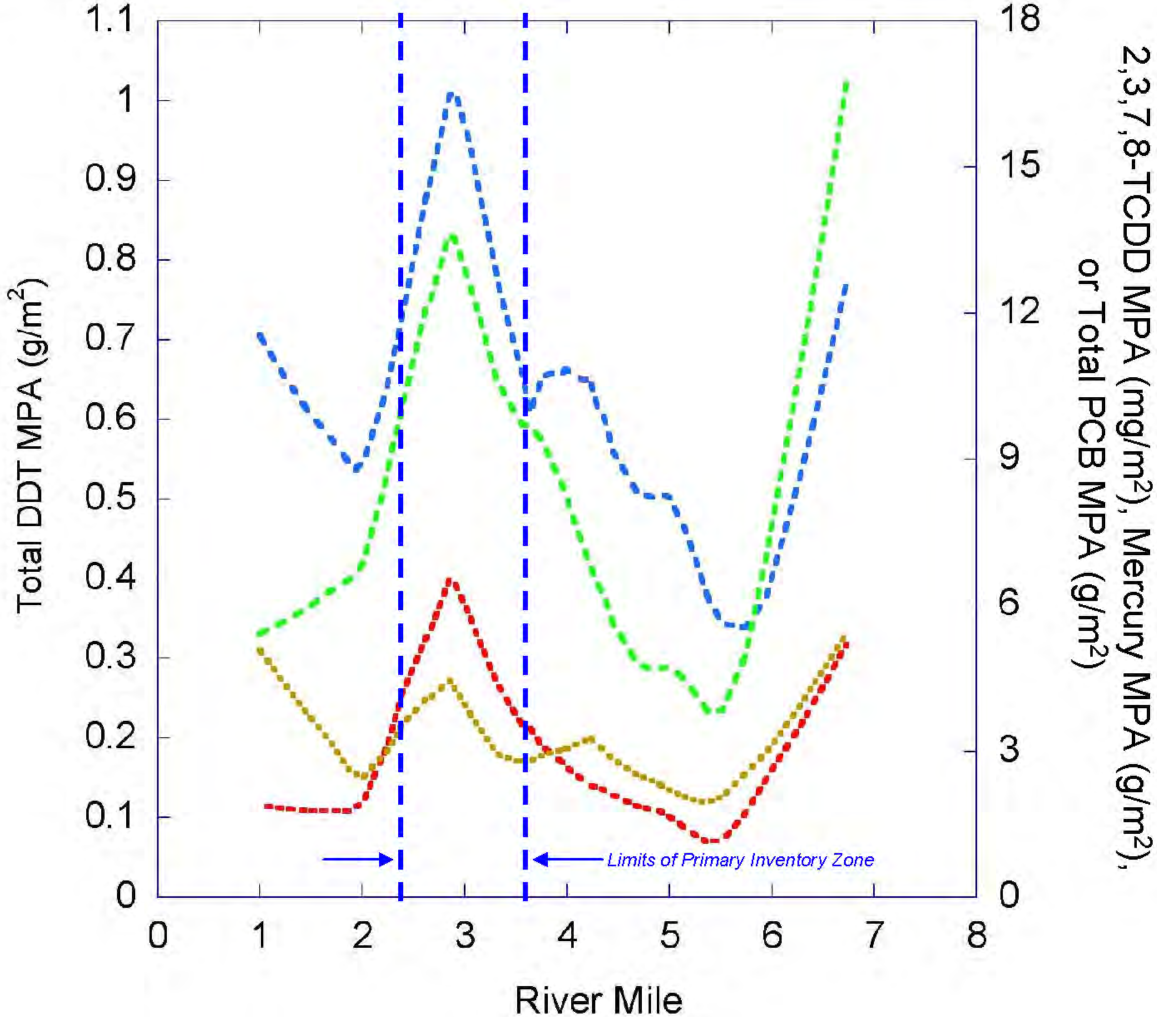
R2-0008904



Legend

- Mercury MPA (g/m^2)
- 2, 3, 7, 8-TCDD MPA (mg/m^2)
- Total PCB MPA (g/m^2)
- Total DDT MPA (g/m^2)

Notes

MPA is mass per unit area.

RI/FS river mile system is used.

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Identification of Primary Inventory Zone

Lower Passaic River Restoration Project

Figure 2-3

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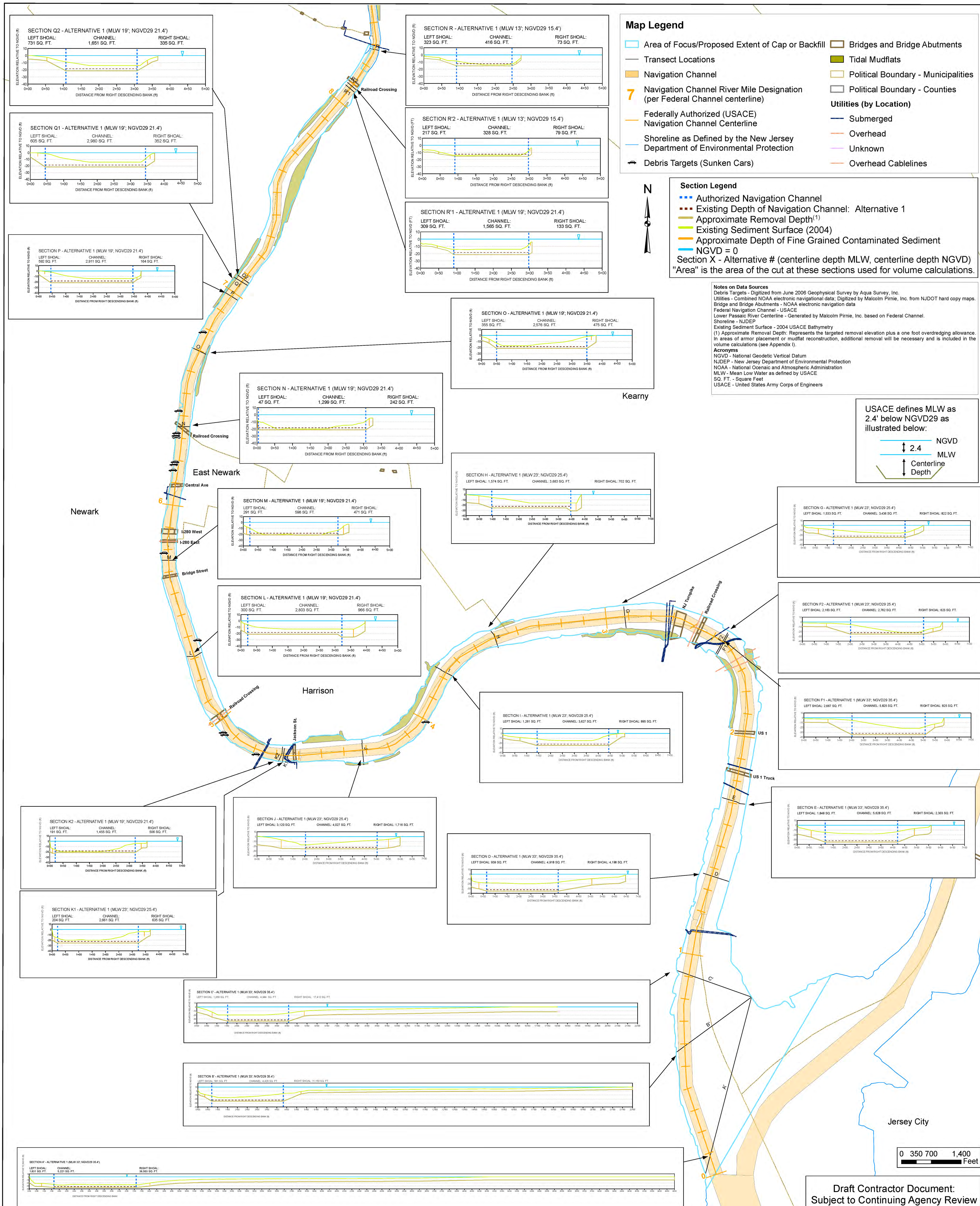

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Conceptual Design
Alternative 1: Removal of Fine-Grained Sediment from Area of Focus

Lower Passaic River Restoration Project

Figure 4-1

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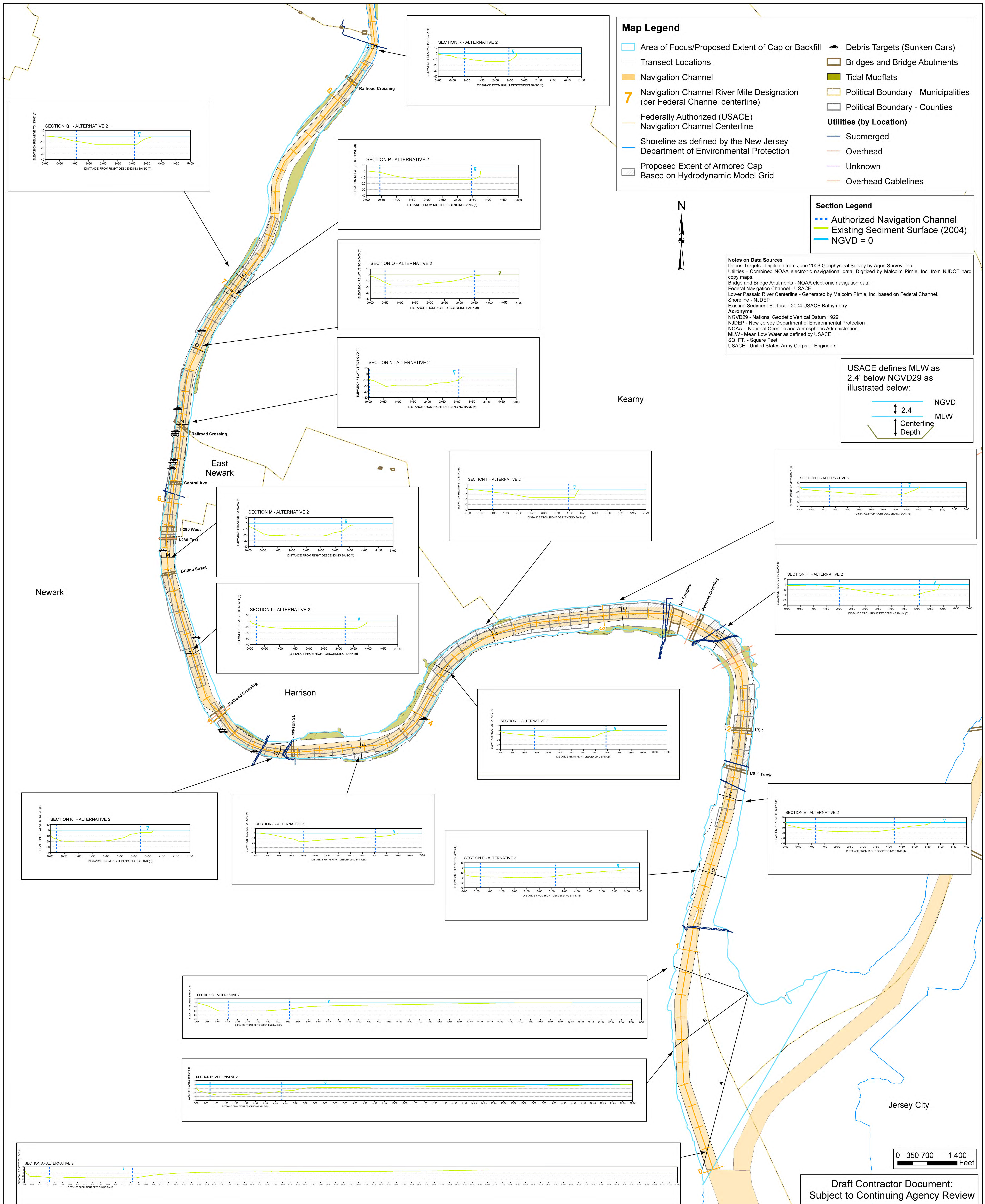

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Conceptual Design
Alternative 2: Engineered Capping of Area of Focus

Lower Passaic River Restoration Project

Figure 4-2

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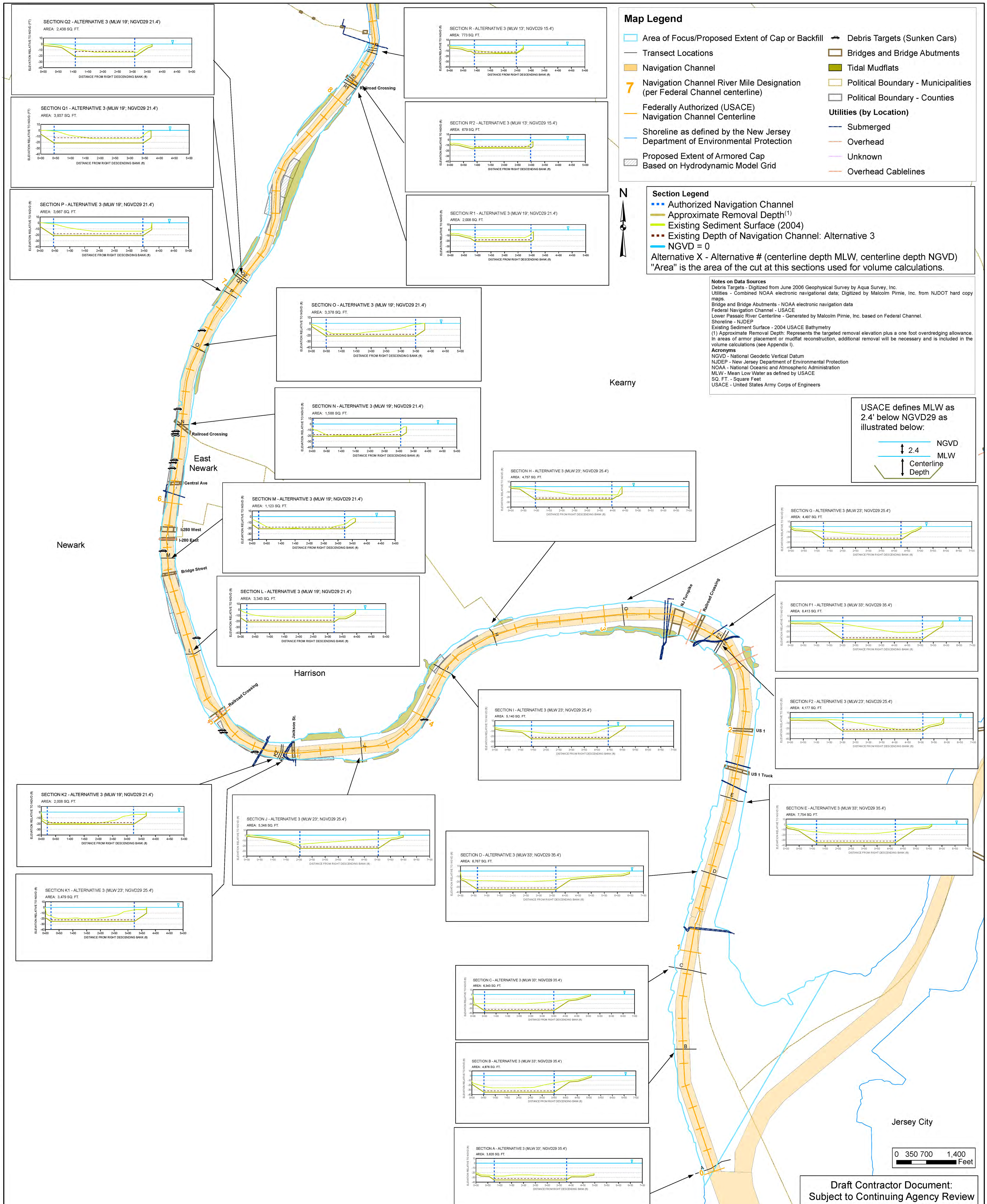

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Conceptual Design
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel
Lower Passaic River Restoration Project

Figure 4-3
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Map Document: (S:\Projects\PASSAIC\MapDocuments\4553001-CERCLA\FS_Concept_Designs\Alternative3.mxd)
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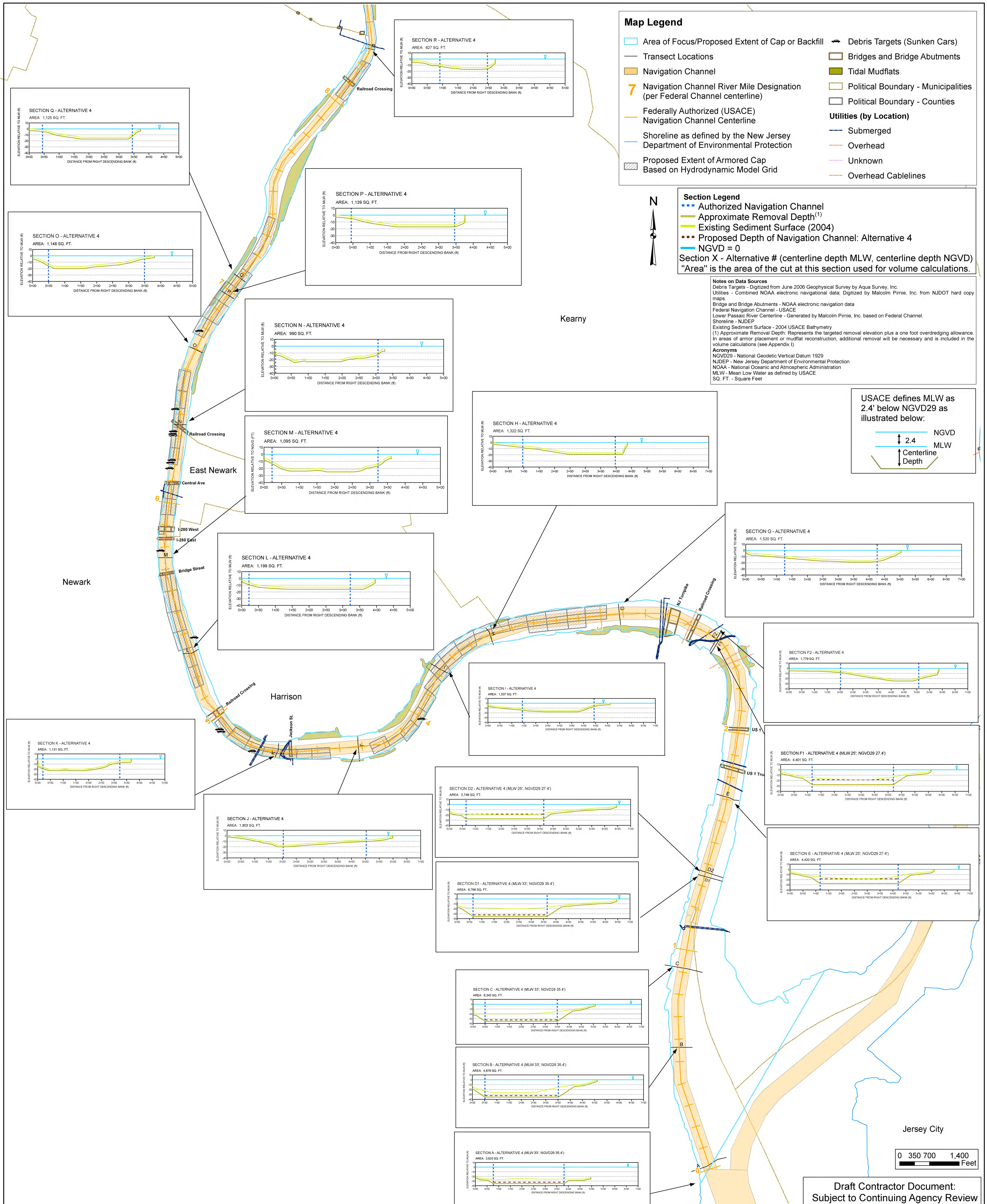

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Conceptual Design
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage
Lower Passaic River Restoration Project

Figure 4-4

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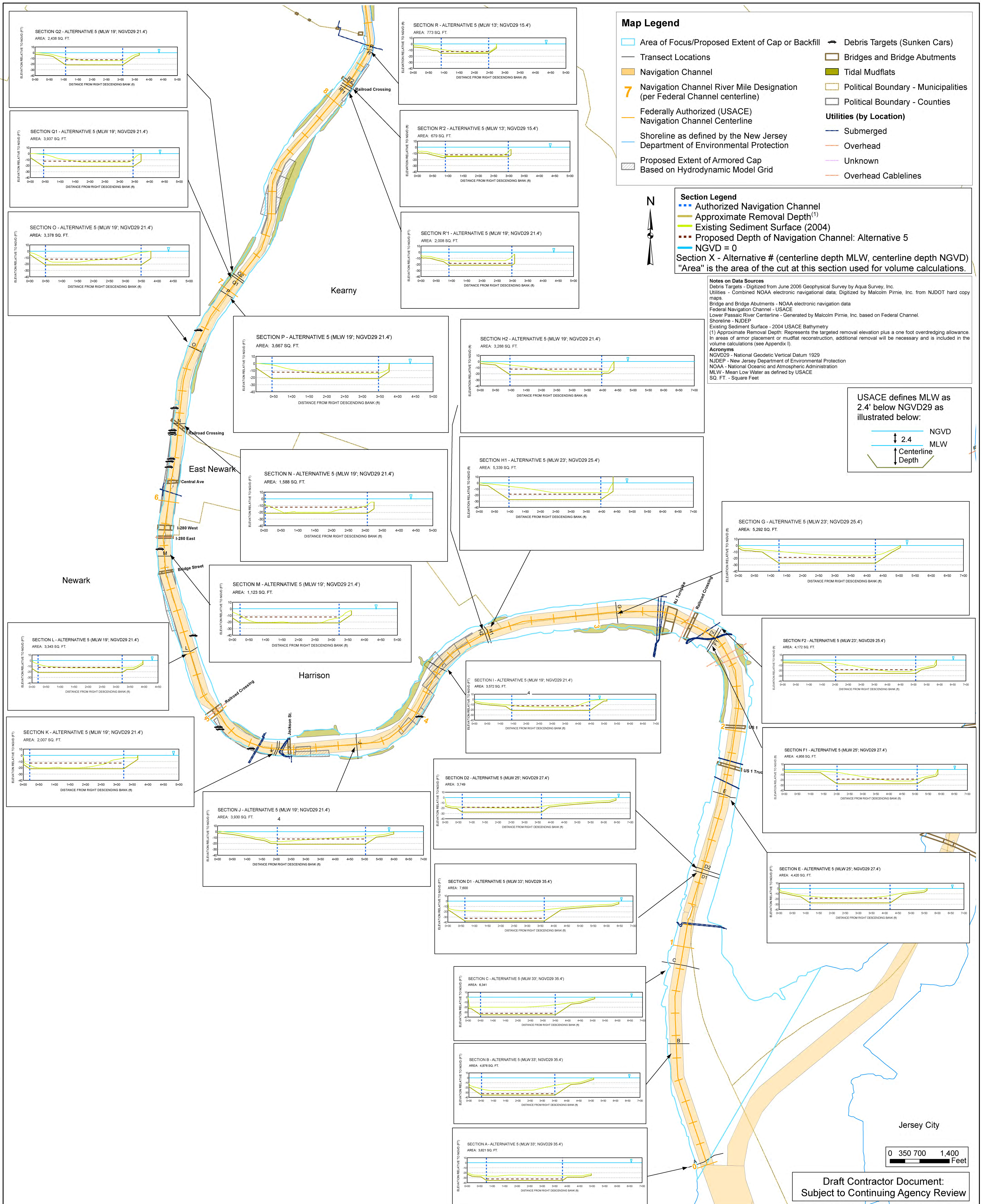

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Conceptual Design
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage

Lower Passaic River Restoration Project

Figure 4-5

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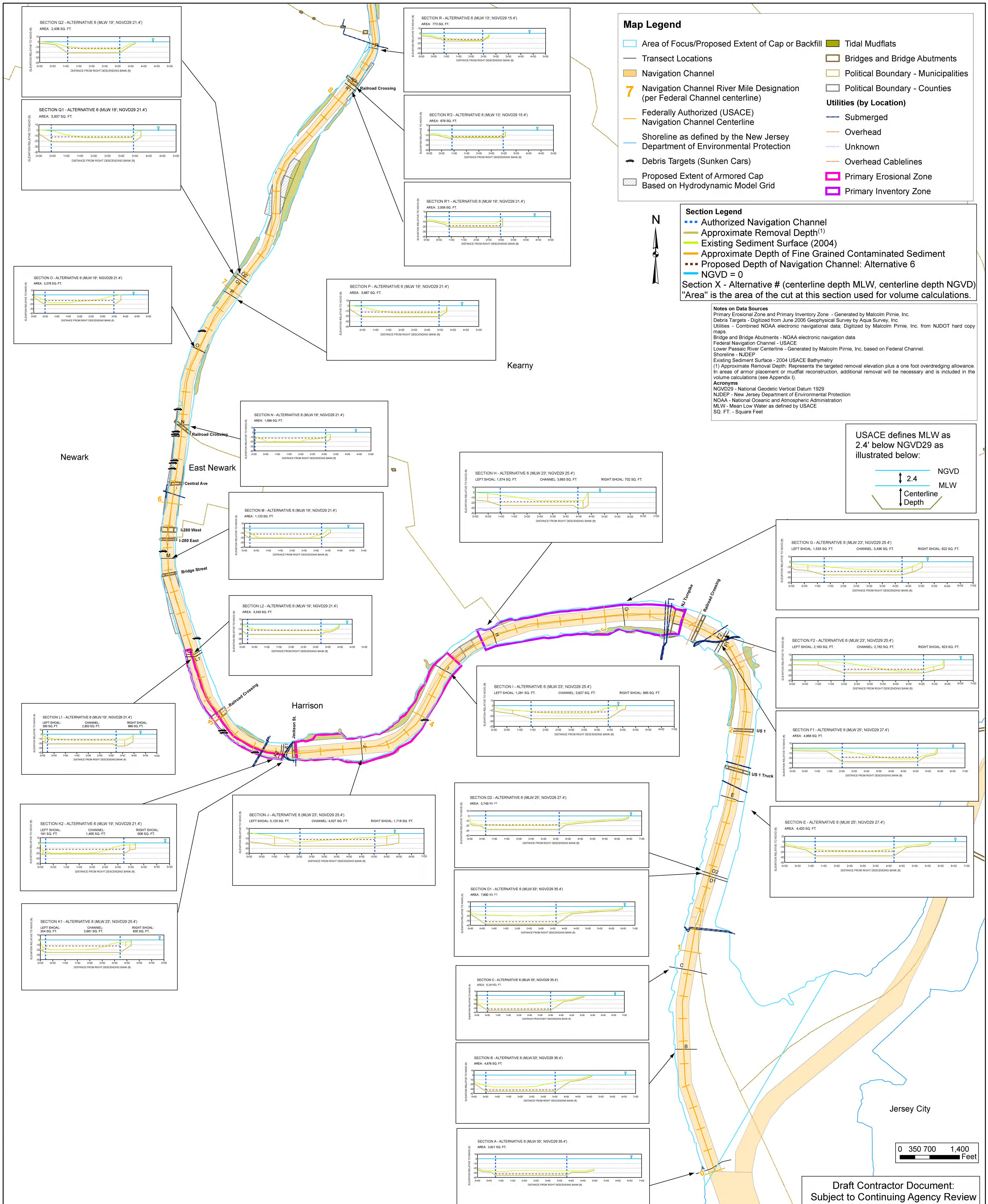

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Conceptual Design
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine-Grained Sediment from Primary Erosional Zone and Primary Inventory Zone
Lower Passaic River Restoration Project

Figure 4-6

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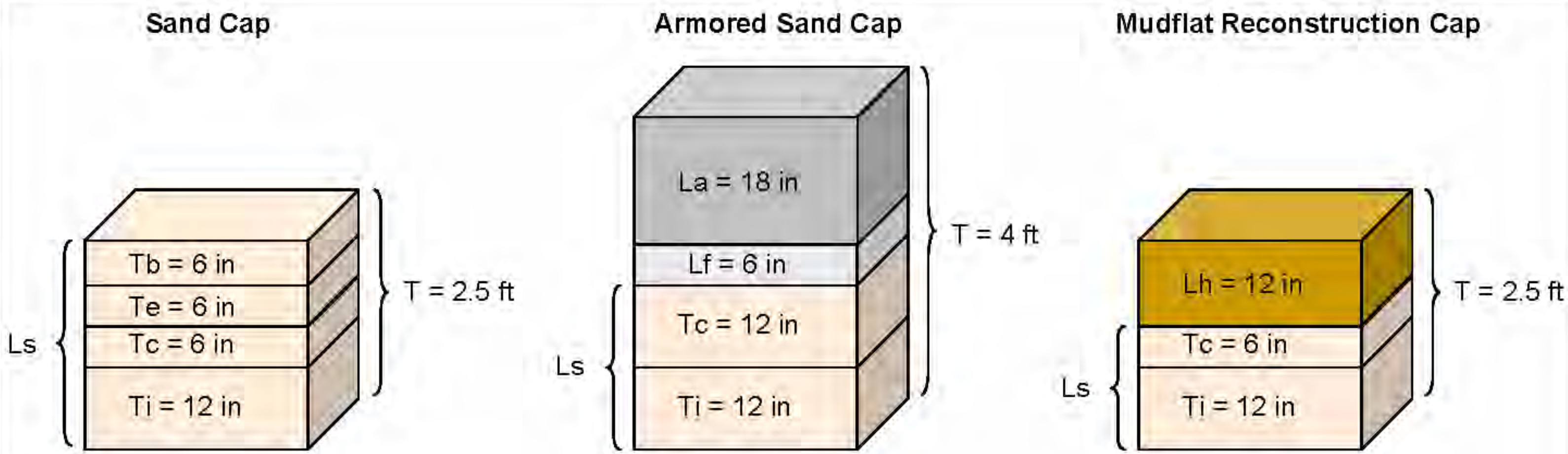

Legend:

Sand Layer (Ls) Components:

Tb – Bioturbation Component

Te – Erosion Component

Tc – Consolidation Component

Ti – Chemical Isolation Component

Lf – Filter Layer

La – Armor Layer

Lh – Habitat Layer

T – Total Thickeness

Sand Cap – The thickness of the sand cap is formed by different components. A chemical isolation component is necessary to prevent contaminant flux. A consolidation component is necessary to maintain cap thickness after the underlying sediments consolidate. A bioturbation component is necessary to prevent benthic organisms from disturbing the chemical isolation component. An erosion component is necessary to protect the bioturbation and chemical isolation components from erosion.

Armored Sand Cap – In order to place a rock armor layer on top of the sand cap, a filter layer of gravel is likely necessary to obtain a more gradual porosity change. Also, since the armor layer protects the cap against erosion, erosion component is not necessary. Consolidation of an armored cap would be greater than a sand cap because of the additional weight of the rocks of the armor layer; therefore the consolidation component of the cap is assumed to be twice as thick that for as a sand cap.

Mudflat Reconstruction Cap – The sand layer of the cap would be a mixture of sand and organic carbon. It is assumed that the chemical isolation and the consolidation component of this layer would be the same as that of a sand cap. The habitat layer encompasses the thickness of the biological active zone (bioturbation component thickness).

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Schematic of Cap Concepts *Lower Passaic River Restoration Project*	Figure 4-7	MALCOLM PIRNIE
	June 2007 Draft	

Tables

Table 2-1: ARARs and TBCs

ARAR or TBC Designation for this Project/ Specific Regulation	General Purpose for the Regulation / Rule	ARAR or TBC	Action, Process, or Discharge That May Apply
Chemical-Specific ARARs			
No ARARs identified			

ARAR or TBC Designation for this Project/ Specific Regulation	General Purpose for the Regulation / Rule	ARAR or TBC	Action, Process, or Discharge That May Apply
Location-Specific ARARs			
Coastal Zone Management Act, §307, 15 CFR 930.30 Federal Consistency Determination	To make sure that federal action comports, to the extent practicable, with CZMA requirements	ARAR	-Placement of bulkheads -Sheet piling within the river -Barge/boat docks -Barge offloading facilities (access) -Boat launches -Bridge abutment bulkhead protection -Utility protection -Dredging, channel dredging, mudflat reconstruction
Endangered Species Act, 16 USC 1531; 50 CFR 402 (1973)	The Endangered Species Act provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered in the U.S. or elsewhere. If any action may have an impact on an endangered species	ARAR	-Preconstruction evaluation
Federal/State Historic Preservation Statute/Regulations	Regulates construction in an area that is protected as a historical site	ARAR	-Preconstruction evaluation
New Jersey Soil Clean-up Criteria	Dictates acceptable levels of contamination in surface or subsurface soils of the State; controls chemical quality of fill to be placed on land, e.g., as landfill cover or other beneficial reuse; provides different levels of protection for residential and non residential areas, and provides protection against impacts to groundwater areas, as designated within New Jersey	TBC	-Reuse or disposal of dredged material -Reuse or disposal of dredged material treated by soil washing -Reuse or disposal of thermally treated dredged material -Reuse or disposal of incinerated dredged material
New Jersey Soil Erosion and Sediment Control Act	Regulates construction that will potentially result in erosion of soils	ARAR	-Preconstruction evaluation -Maintenance during construction, and thereafter
New Jersey Freshwater Wetlands Protection Act, N.J.A.C. 7:7A	Regulates construction or other activities (including remedial action) that will have an impact on wetlands	ARAR	-Preconstruction design analysis
Flood Hazard Area Control Act, N.J.S.A. 15:16A-50 et seq.	Regulates activities (including remedial action) that will impact stream carrying capacity or flow velocity to avoid increasing impacts of flood waters	ARAR	-Construction and development in the flood plain or flood fringe -Excavation or filling in the flood plain or flood fringe

ARAR or TBC Designation for this Project/ Specific Regulation	General Purpose for the Regulation / Rule	ARAR or TBC	Action, Process, or Discharge That May Apply
Action-Specific ARARs			
Rivers & Harbors Act, 33 USC 403	Coordination of activities occurring in navigable waters	ARAR	-Barge movement and anchoring -Dredge movement and anchoring -Sheet piling -Construction of offloading facilities
Water Quality Certification, Clean Water Act §401	Requires assurance that action taken meets applicable federal/state water quality limitations	ARAR	-Requires that actions during dredging, during other site activities, and after remediation will protect the quality of the water. - Non permitted discharges from the barges and support vessels -Minimizing resuspension of sediments, dredging, offloading sediments, placement of capping material, slope management, mudflat reconstruction, etc.
Clean Water Act §404	Regulates the discharge of dredged or fill material into navigable waters of the United States; also regulates the construction of any structure in navigable waters	ARAR	-Placement of dredged borrow material in river -Movement of dredged material within the remediation areas -Reconstruction of mudflat areas -Placement of capping / armoring materials
New Jersey Pollutant Discharge Elimination System (NJPDES) rules: N.J.A.C. 7:14A	Regulate the direct and indirect discharge of pollutants to the surface water and ground water	ARAR	-Onsite treatment - soil/sediment washing liquid waste stream -Onsite thermal treatment - resulting from sediment dewatering prior to treatment -Onsite treatment or pre-treatment - resulting from various physical sediment dewatering methods -Barge dewatering activities

Table 2-1: ARARs and TBCs

ARAR or TBC Designation for this Project/ Specific Regulation	General Purpose for the Regulation / Rule	ARAR or TBC	Action, Process, or Discharge That May Apply
Action-Specific ARARs			
Federal Pretreatment Regulations For Existing And New Sources Of Pollution - 40CFR403, and as Adopted by NJ Utility Authorities	Provide pretreatment criteria that waste streams must meet prior to discharge to Publicly Owned Treatment Works (POTW)	ARAR	-Onsite treatment - soil/sediment washing -Onsite thermal treatment – resulting from sediment dewatering prior to treatment -Offsite incineration – sediments and water -Onsite treatment or pre-treatment - resulting from sediment dewatering -Barge dewatering activities
Resource Conservation and Recovery Act (RCRA), 40 CFR §§ 261, 262, 264, 265, 268	Evaluate and control material that contains a listed waste, or that displays a hazardous waste characteristic based on the Toxicity Characteristic Leaching Procedure (TCLP) test. Regulate storage, treatment and disposal of listed or characteristic waste unless an exemption applies	ARAR	-Evaluation and off-site disposal of dredged material -If dredged material is removed but replaced in water within the Area of Contamination, which for this FFS includes the Lower Passaic River, Newark Bay and areal extent of contamination, RCRA land disposal regulations are not triggered
Toxic Substances Control Act (TSCA) 40 CFR Part 761 (1976)	Regulates PCBs from manufacture to disposal.	ARAR	- Removal or in-situ management of sediments with PCB concentrations greater than 50 milligram/kilogram (ppm) - Atomization and air dispersion of PCB-containing sediments during dredging, barge transportation, offloading or processing of dredged materials -Transportation and disposal of sediments containing PCB concentrations greater than 50 ppm
Hazardous Waste Transportation: 49 CFR 107, 171, 172 and potentially 174, 176 or 177	Regulates the transportation of hazardous materials, and include the procedures for the packaging, labeling, manifesting and transporting of hazardous materials.	ARAR	-Transportation of dredged material and any other hazardous materials or wastes generated during remediation via truck, rail or barge to off-site locations
Stormwater Management Rules, N.J.A.C. 7:8 (unless it falls under the Coastal Area Facility Review Act, N.J.S.A. 13:19-1 et seq.)	Establish the design and performance standards for stormwater management measures.	ARAR	- Construction and operation of any onsite treatment or support facilities that may generate storm water runoff.
Clean Air Act, amended 1990, National Ambient Air Quality Standards: 40 CFR part 50	Requires USEPA to set standards for pollutants considered harmful to public health and the environment; standards are established for six primary and secondary pollutants.	ARAR	- Onsite activities resulting in releases to the air, including operation of equipment, dredging and open barge transport of dredged material - Onsite treatment - soil/sediment washing - Onsite thermal treatment - sediments - Offsite incineration treatment – sediments and water - Onsite treatment or pre-treatment - resulting from sediment dewatering
The Clean Air Act amended 1990: Hazardous Air Pollutants, Section 112.	Establishes restrictions on emissions for area sources, carcinogenic pollutants, etc. (NESHAPS)	ARAR	-National Emission Standards for Hazardous Air Pollutants (NESHAPS) final rule for site remediation activities
N.J.A.C. 7:27 Subchapter 8. Permits and Certificates, including NJDEP Technical Manual 1003. December 1994.	Governs emissions that introduce contaminants into the ambient atmosphere for a variety of substances and from a variety of sources; requires risk assessment if a process or activity emits certain contaminants regarded as air toxics, per NJDEP "Technical Manual 1003 – Air Quality Regulation Program, Bureau of Air Quality Evaluation, Guidance on preparing a Risk Assessment Protocol for Air Contaminant Emissions." Revised December 1994 (may also be initiated by an odor, visual, or particulate complaint.)	ARAR	- Onsite treatment - soil/sediment washing - Onsite thermal treatment - sediments - Offsite incineration treatment – sediments and water (if in New Jersey) - Onsite treatment or pre-treatment - resulting from sediment dewatering - Dredging, barge transportation, offloading, may also be triggered (for NJDEP) if odor, particulates, and opacity complaints are lodged by citizens/communities.
New Jersey Technical Requirements for Site Remediation, N.J.A.C 7:26E-1.13, -2.1, -2.2, -3.4, -3.8, -3.11, -4.5 and -4.7:	Identify the minimum technical requirements that must be followed in the investigation and remediation of any contaminated sites in New Jersey. Both numeric and narrative standards for remediation of groundwater and surface water are listed. The regulations also describe the requirements for quality assurance project plans (QAPPs) and requirements for certified labs and analysis methods. Site investigation regulations describe sampling requirements and rationales for sampling surface water, wetlands and sediment and requirements for the development of ecological evaluations.	ARAR	All activities associated with investigation and remediation.

Table 2-7 PRG Selection

			Ecological PRGs			Cancer Threshold Sediment Concentration Based on # Fish Meals[f] per Year for an Adult															Noncancer Threshold Sediment Concentration Based on # Fish Meals[f] per Year					Background Values[g]	Selected PRG	
			Sediment PRGs			40 meals per year[f]			12 meals per year			6 meals per year			2 meals per year			1 meal per year										
CASRN	Units	Chemical	Benthos[b]	Wildlife[c]	Lowest	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	1.E-06	1.E-05	1.E-04	40 meals per year	12 meals per year	6 meals per year	2 meals per year	1 meal per year	Above Dundee Dam 2007	Selected Value	Rationale
Inorganics																												
7440-50-8	ng/g	Copper	34,000	13,318	Wildlife PCL																					80,000	80,000	Background
7439-92-1	ng/g	Lead	46,700	10,606	Wildlife PCL																					140,000	140,000	Background
7439-97-6	ng/g	Mercury[a]	150	37	Wildlife PCL	Classification — C; possible human carcinogen; There is no quantitative estimate of carcinogenic risk from oral exposure															2,814	9,380	18,759	56,278	112,555	720	720	Background
Polycyclic Aromatic Hydrocarbons (PAH)																												
SUM_LOW_PAH	ng/g	Low Mol Wt PAH	552	-	NOAA ER-L																					8,900	8,900	Background
SUM_HIGH_PAH	ng/g	High Mol Wt PAH	1700	-	NOAA ER-L																					65,000	65,000	Background
PCB Aroclors																												
SUM_PCB	ng/g	Total PCB	23	365	NOAA ER-L	2	19	187	6	62	622	12	124	1,244	37	373	3,731	75	746	7,461	26	85	171	512	1023	660	660	Background
Pesticides/Herbicides																												
SUM_TDDT	ng/g	DDx	1.6	19	NOAA ER-L																					91	91	Background
12789-03-6	ng/g	Total Chlordane	-	-	-	1	12	120	4	40	399	8	80	798	24	239	2393	48	479	4786	72	239	479	1436	2871	92	92	Background
60-57-1	ng/g	Dieldrin	0.02	271	NOAA ER-L																					4.3	4.3	Background
Polychlorinated dibenzodioxin/furan (PCDD/F)																												
1746-01-6	ng/g	2,3,7,8-TCDD	0.00318[d]	0.0025[e]	Wildlife PCL	0.00027	0.0027	0.027	0.00091	0.0091	0.091	0.0018	0.018	0.18	0.0055	0.055	0.55	0.011	0.11	1.1	No toxicity data at this time					0.0020	0.0020	Background

Notes:

a. All occurrences of mercury assumed to be methylated for purposes of this evaluation.

b. ER-L = Effects Range-Low from Long *et al.*, 1995, except where noted.

c. Derived as described in the FFS COPEC Technical Memorandum (Battelle, 2007).

d. Benthic benchmark derived by USFWS using sediment chemistry for Arthur Kill and oyster effect data presented in Wintermyer and Cooper, 2003.

e. Wildlife value derived from USEPA, 1993.

f. 40 meals/year = ~1 fish meal every 1.5 weeks; 12 meals/year = 1 fish meal every month; 6 meals/year = 1 fish meal every other month; 2 meals/year = 1 fish meal every six months.

g. Values rounded to the nearest 2 significant digits.

Table 2-9: Forecasted COPC/COPEC Concentrations in Surface Sediments for Year 2048

Analyte	Forecasted Concentrations in Surface Sediment for the No Action Alternative		Forecasted Concentrations in Surface Sediment for Active Remediation of the Area of Focus			Forecasted Concentrations in Surface Sediment for Active Remediation of the Primary Erosional Zone		
	Forecasted 2048 Concentration	Percent Reduction from 2005 to 2048	Forecasted 2048 Concentration	Percent Reduction in 2018 due to Remediation	Percent Reduction from 2005 to 2048	Forecasted 2048 Concentration	Percent Reduction in 2018	Percent Reduction from 2005 to 2048
Mercury (mg/kg)	0.25	81	0.17	33	91	0.22	11	88
Lead (mg/kg)	68	67	60	12	71	65	4	69
Copper (mg/kg)	43	63	38	12	75	41	4	73
Total Chlordane (μg/kg)	36	49	36	Constant	49	36	Constant	49
DDE (μg/kg)	9.2	77	5.7	39	89	8.0	13	85
DDD (μg/kg)	13	77	7.9	39	89	11	13	85
DDT (μg/kg)	2.8	77	1.7	39	89	2.4	13	85
Total DDx (μg/kg)	25	77	15	39	89	22	13	85
Dieldrin (μg/kg)	4.2	Constant	3.5	20	40	3.9	7	33
2,3,7,8-TCDD (ng/kg)	45	83	6.5	86	98	32	30	93
PCDD/F TEQ (μg/kg)	0.046	83	0.0066	86	99	0.032	30	93
Total PCB (μg/kg)	240	88	160	32	84	210	11	79
PCB TEQ Mammal (μg/kg)	0.0019	86	0.0013	32	98	0.0017	11	98
PCB TEQ Bird (μg/kg)	0.030	86	0.020	32	98	0.026	11	98
PCB TEQ Fish(μg/kg)	0.00016	86	0.00011	32	98	0.00014	11	98
LPAH (mg/kg)	5.3	Constant	5.2	2	Constant	5.3	1	Constant
HPAH (mg/kg)	35	Constant	35	Constant	Constant	35	Constant	Constant

Concentrations rounded to two significant figures, whenever possible.
mg/kg – milligrams per kilogram of sediment
μg/kg – micrograms per kilogram of sediment
ng/kg – nanograms per kilogram of sediment

Table 3-1a: General Response Action: No Action

General Response Action Description: No Action						
Under the No Action response, no actions involving removal, containment, treatment, engineering controls, or new institutional controls are implemented. A No Action response may, however, include some type of environmental monitoring to verify that unacceptable exposures to hazardous substances do not occur in the future (USEPA, 1988).						
Technology Class	**Process Options**	**Process Option Description**	**Implementability**	**Effectiveness**	**Cost**	**Retained**
N/A	N/A	N/A	The No Action response is easily implementable since only monitoring is required. According to USEPA guidance (USEPA 2005), a no-action decision may be appropriate when a site poses no current or potential threat to human health or the environment, when CERCLA does not provide the authority to take remedial action, or when a previous response has eliminated the need for further remedial response. While the Area of Focus has unacceptable human health and ecological risk levels (see Section 2.4.1 "Current Risk Characterization"), the NCP requires that the No Action alternative be developed as one of the potential remedial actions to be considered in a Feasibility Study.	The No Action reponse would not be effective in reducing mobility, toxicity, or volume of contaminants within a reasonable time period. The contaminated sediment present in RM0 to RM8 would continue to erode and act as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary . Human health and ecological risks would remain essentially unchanged from those identified in Section 2.4.1 "Current Risk Characterization".	Low	Yes

Table 3-1b: General Response Action: Institutional Controls

General Response Action Description: Institutional Controls						
Institutional controls are defined as non-engineering, administrative, and/or legal controls at a site, intended to prevent or reduce human exposure to hazardous substances.						
Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
N/A	N/A	N/A	Institutional controls are potentially applicable and technically implementable. Currently, institutional controls in the form of fish consumption advisories are in place for the contaminants dioxin and PCB in the Area of Focus. Additional institutional controls may include continuation or extension of fish consumption advisories, limitations on recreational use, restrictions on private sediment disturbance activities, and dredging moratoriums.	Institutional controls are potentially effective for reducing risk to human health by limiting exposure, but not effective in reducing mobility, toxicity, or volume of contaminants within a reasonable time period. This response action would be more effective if implemented as a component of alternatives comprising active remedial measures rather than alone.	Low.	Yes

Table 3-1c: General Response Action: Monitored Natural Recovery

<table>
<tr><td colspan="7">General Response Action Description: Monitored Natural Recovery</td></tr>
<tr><td colspan="7">The USEPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, 2005) identifies MNR as a potential remedial alternative for managing contaminated sediments. This guidance document defines MNR as a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments. USEPA's guidance document outlines the site conditions under which MNR should receive detailed consideration:

• Natural recovery is not incompatible with anticipated land use or new structures.
• Expected human exposure is low and/or can be reasonably controlled by institutional controls.
• Sediment bed is reasonably stable and likely to remain so.
• Sediment is resistant to resuspension.
• Contaminant concentrations in biota and in the biologically active zone of the sediment are moving towards risk-based goals on their own.
• Natural recovery processes have a reasonable degree of certainty to continue at rates that will contain, destroy, or reduce the bioavailability or toxicity of contaminants within an acceptable time frame.
• Contaminants already readily biodegrade or transform to lower toxicity forms.
• Contaminant concentrations are low and cover diffuse areas.
• Contaminants have low ability to bioaccumulate.
• Knowledge of other potential upstream contaminant sources.</td></tr>
<tr><th>Technology Class</th><th>Process Options</th><th>Process Option Description</th><th>Implementability</th><th>Effectiveness</th><th>Cost</th><th>Retained</th></tr>
<tr><td>Physical Degradation</td><td>Sedimentation, Advection, Diffusion, Dilution, Dispersion, Bioturbation, Volatilization.</td><td>N/A</td><td rowspan="3">MNR is implementable, as the processes associated with natural recovery are likely occurring in the area of focus to some extent. For example, scour and transport will affect recovery processes in high-energy environments, while sedimentation and bioturbation will affect natural attenuation of sediments in moderately depositional areas. However, other processes occurring in the Area of Focus likely slow natural recovery. For example, while sediment burial can contribute to the recovery process, ongoing erosion of contaminated sediment appear to prevent the effective isolation of contaminant inventory. Likewise, biodegradation of the primary COPCs is likely not occurring in the river since toxic, heavy metals are not biodegradable and many organic COPCs are not easily biodegraded.</td><td rowspan="3">Multiple lines of evidence are generally needed to confirm that natural recovery processes are occurring to a significant degree at a site. Biota contaminant concentrations, surface sediment concetrations, water column concentrations, and sediment transport and deposition rates were analyzed to find evidence of natural recovery. It was found that historical biological and historical water column data are not appropiate to conclude if natural recovery is occurring in the Area of Focus. Surface sediment concentrations indicate that natural recovery is occurring to some extent on the area of focus; however, the process is occurring at a rate that is incompatible (i.e., too slow) with its application as an early action. Since no active remedial measures would be implemented under MNR, the mobility and toxicity of contaminants could potentially increase due to the erosional zones in the area. MNR would not be effective as an early action since the processes would not be effective in reducing mobility, toxicity, or volume of contaminants within a reasonable time period. This response action would be more effective if implemented as a component of alternatives comprising active remedial measures rather than alone.</td><td>Low.</td><td>Yes, as follow-on to active remediation</td></tr>
<tr><td>Biological Degradation</td><td>Biodegradation, Biotranformation, Phytoremediation, Biological Stabilization.</td><td>N/A</td><td>Low.</td><td>Yes, as follow-on to active remediation</td></tr>
<tr><td>Chemical Processes</td><td>Sorption, Oxidation/ Reduction Processes.</td><td>N/A</td><td>Low.</td><td>Yes, as follow-on to active remediation</td></tr>
</table>

Table 3-1d: General Response Action: Containment

General Response Action Description: Containment
Sediment containment is generally achieved via the placement of a subaqueous covering or a cap of clean material over contaminated material that remains in place. Containment remedies can generally be implemented more rapidly and at a lower cost than sediment removal, because containment does not require siting of large materials handling facilities and there can be little to no removal, transport, and disposal of contaminated sediment required. Capping achieves mass remediation via the following mechanisms: • Physical isolation of contaminated sediments from the overlying water column and from direct contact with aquatic biota. • Add sufficient physical stability to contaminated sediment to reduce resuspension and transport to other sites. • Reduction in flux of colloidal-bound contaminants into the water column. The major limitation of containment technologies is that the contaminated sediment remains in place, where contaminants could be exposed or dispersed if the containment system is significantly disturbed. Other limitations include reduced water depth, potentially impacting flood-carrying capacity and navigation. In the case of low permeability caps, providing adequate groundwater transmissivity may limit applicability to localized areas of a water body. A limitation in colder regions is the potential erosion of the cap due to ice jam formations. According to the Cold Regions Research and Engineering Laboratory (CRREL) Ice Jam Database, there have been three ice jam events recorded in the Passaic River at Chatham, NJ in the freshwater section of the river. Although ice forms in the Lower Passaic River, no records of ice jams were found in the Area of Focus. Therefore, cap erosion due to ice jams is not considered a major concern for the Area of Focus. However, ice scour at the shoreline could be an issue. The technology classes considered under containment include structural containment and capping. Structural containment may be achieved via the construction of a silt trap. Caps are generally constructed of granular material such as clean sediment, sand or gravel. A more complex cap design may include geotextiles, liners, and other permeable or impermeable elements in multiple layers. In addition, reactive agents that may attenuate the flux of contaminants (i.e., active caps) can be incorporated.

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Capping	Engineered Caps	Engineered caps involve the placement of sand or other suitable cover material over the top of contaminated sediments. Coarse-grained materials are typically preferred as cap materials over fine-grained materials. The latter are more difficult to place evenly, cause more turbidity during placement, and are more susceptible to erosion under high flow conditions. A variety of methods are available for constructing conventional caps. Mechanical methods rely on the gravity settling of cap materials in the water column and may be depth-limited in their application. Capping materials may also be placed using bottom-dump scows if provisions are made for controlled opening or movement of the barges. Hydraulic methods offer more precise placement, although the energy required for slurry transport may require dissipation to prevent resuspension of contaminated sediment. Specialized equipment for hydraulic spreading of sand for capping has been used by the Japanese (USEPA, 1994). Additional discussion of equipment and placement techniques for granular cap materials may be found in the ARCS Remediation Guidance Document (USEPA, 1994). . A common variation on engineered sand caps is the addition of armoring material to add physical stability in erosive settings. The primary capping material (e.g., sand) is typically covered with stone or another armoring material. Filter layers may be required when the armor stone is substantially larger than the base cap material. Methods that have been used for placing armor stone include placing by hand; machine placing, such as from a bucket; and dumping from trucks and spreading by bulldozer (USEPA, 1994). In addition, some of the methods discussed above for placement of granular cap materials may be used to place armor layer materials.	This process option is Implementable, but capping options could result in permanent restrictions to future site use for navigational purposes unless sediments are removed prior to cap placement, as necessary to maintain navigation channel depth. Water depths in RM0 to RM8, which range from approximately 12 to 30 feet, would likely not present insurmountable technical challenges for mechanical placement. In the Hazardous Substance Research Centers/South and Southwest "Summary of Contaminated Sediment Capping Projects", capping projects with water depths greater than 100ft are not uncommon. Upriver flooding impacts would also need to be examined. Long-term monitoring and cap maintenance would be required for any capping scenario. In addition, impacts to benthic communities must be considered. Conventional sand caps with armor layers have been successfully placed over contaminated sediments in many environments, including several large sites (Bailey and Palermo, 2005).	As of 2004, *in situ* capping has been selected as a component of the remedy for contaminated sediment at approximately 15 Superfund sites (USEPA, 2005). According to SedWebSM (http://www.sediments.org/capsummary.pdf) in situ capping has been used at 109 contaminated sediment projects throughout the United States, Europe and Japan. Capping is considered effective at isolating low-solubility and highly sorbed contaminants such as those found in the Lower Passaic River. As discussed in the USEPA guidance document for sediment remediation, caps should be designed to withstand forces associated with up to a 100-year storm.	Capping costs are expected to be low to moderate depending on the type of capping material, the thickness of the cap, and the method of construction. The use of a nearby borrow source for coarse grained sand material (either subaqueous or land-based) would result in lower costs. Additional costs may result if stone or another stabilizing material were to be used. Long-term costs include periodic monitoring of the cap and cap maintenance, as required.	Yes

Table 3-1d: General Response Action: Containment

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Capping (continued)	Active Caps	Active caps involve the incorporation of materials such as activated carbon, iron filings, apatite, or other agents into the base capping material to enhance adsorption or in-situ chemical reaction. This approach is intended for circumstances in which contaminants are mobile and are expected to migrate through the cap as dissolved constituents in the pore water.	Active caps are implementable, but limitations are similar to those for conventional caps, namely reduced water depth, potentially impacting flood-carrying capacity and navigation, and potentially reduced permeability compared to native silt.	Based on professional judgment, the limited groundwater data, and the Area of Focus sediment's high organic content, it is unlikely that groundwater contaminant flux, even with enhanced transport potential from dissolved organic compounds, will approach the magnitude of the hydrophobic contaminant contribution presented by sediment resuspension and transport. Thus, the use of an active cap that mitigates pore water contributions of hydrophobic compounds would likely result in minimal added effectiveness compared to conventional caps. In addition, there is limited field experience with active caps (with perhaps the exception of caps amended with organic material or top soil); therefore, it is difficult to predict effectiveness.	Low to high, depending on flux of pore water and desired effectiveness in remediating either selected contaminants or entire suite of contaminants.	No
	Geotextile Caps	Geotextile cap layers may be used to reduce mixing and displacement of sediment with the cap material. Placement of geosynthetic fabrics typically requires the coordinated action of several crews and vessels. The material would need to be anchored quickly, especially since tidal cycles result in changing conditions.	While installation of this material over a large area may be exceptionally challenging for construction, geotextile caps may be considered during the design phase, perhaps to allow for conventional capping of sediments in selected areas that may otherwise be too soft to support a cap or to allow for improved cap stability on navigation channel side slopes.	Porous geotextile cap layers do not achieve sediment isolation, but serve to reduce the potential for mixing and displacement of the underlying sediment with the cap material. The geotextiles allow the sediments to consolidate and gain strength under the sand cap load. They are potentially effective in the short/medium term in reducing mobility of contaminants. Long term effectiveness of geotextiles placed in a dynamic system over a large area are unknown.	Low to moderate. Purchase and placement of geotextile would be more costly than traditional capping methods.	Yes
	Clay Caps	Clay aggregate materials (e.g., AquaBlok™) consist of a gravel/rock core covered by a layer of clay mixed with polymers that expand in water, decreasing the material's permeability. The hydrated particles are cohesive and are more resistant to erosion than sand. In laboratory flume tests there was little loss of AquaBlok™ particles at a current velocity of 3 feet per second when compared with the amount of sand lost at the same velocity (TAMS, 2002). Standard construction equipment such as front-end loaders, conveyors, and barges may be used to place AquaBlok™.	The use of a clay cap may not result in suitable substrate for habitat, and could potentially require that additional, suitable material be placed. Furthermore, groundwater recharge issues (e.g., disturbances in flow patterns) could result from the associated reduction in permeability. In the case of low permeability caps, providing adequate groundwater transmissivity may limit applicability to localized areas of a water body.	The use of clay caps over a large area has not been documented, therefore effectiveness is unknown.	Low to moderate. Purchase and placement of clay would be more costly than traditional capping methods.	No

Table 3-1d: General Response Action: Containment

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Structural Containment	Silt Trap	Structural containment systems, such as silt traps, create conditions within hydraulic systems that restrict or reduce flow to such an extent that suspended sediment is removed from suspension. These containment structures are often used in stream bank stabilization, stormwater management systems, and other systems where either erosion of sediments or migration of sediments is a concern.	In considering this approach, previous geochemical evaluations are informative; they have shown that the area of focus sediments have migrated through extensive low velocity regions in the system (such as Newark Bay itself) and into outlying channels (e.g., Kill van Kull and Arthur Kill). Thus, an engineered silt trap to reduce velocities further than those velocities associated with the hydrodynamic conditions present in Newark Bay, such that silt particles suspended in the area of focus that currently migrate out of Newark Bay would be intercepted and deposited at the mouth of the river, would potentially require a structure of infeasible depth and/or footprint. The implementability of silt trap is dependent on its size.	The construction of a structural containment system within the area of focus would not reduce erosion of contaminated sediments, but could potentially reduce the flux of sediment between the river and Newark Bay. A preliminary evaluation was performed to examine whether the excavation of a large silt trap at the mouth of the Passaic River could create a low velocity region in which suspended sediment particles would settle due to the dominance of gravity forces over buoyant and advective forces. A memorandum providing the calculations for the silt trap evaluation is provided in Appendix E : "Engineering Memoranda." While structural containment systems are likely to be technically implementable, the analysis indicates that a silt trap would not be effective due to the hydrodynamic and sediment transport conditions present in the Area of Focus.	Moderate. Material dredged to create silt trap would require treatment, and silt trap would require annual maintenance to maintain effectiveness.	No

General Response Action Description: In Situ Treatment

In situ treatment of sediments refers to chemical, physical, or biological techniques for reducing contaminant concentrations and/or contaminant mobility while leaving the contaminated sediment in place. Although in situ process options are frequently employed for remediation of contaminated soil and groundwater, few successful adaptations of these process options for full-scale treatment of contaminated sediments have been reported in the literature. Technology classes that were considered include immobilization, physical extractive technologies, biological treatment, and chemical treatment. In situ thermal techniques, such as vitrification or thermal desorption, are not known to have applicability to subaqueous sediments (which have an effectively infinite saturation gradient) and are therefore not discussed.

<table>
<tr><th>Technology Class</th><th>Process Options</th><th>Process Option Description</th><th>Implementability</th><th>Effectiveness</th><th>Cost</th><th>Retained</th></tr>
<tr><td rowspan="3">Immobilization</td><td>Contaminant Fixation</td><td rowspan="3">Immobilization refers to treatment processes such as solidification, stabilization, and encapsulation that physically or chemically reduce the mobility of hazardous constituents in a contaminated material. In solidification, the contaminants are physically bound within a solidified matrix. Stabilization is a process by which a contaminated material is converted to a more chemically stable form. In many applications, both solidification and stabilization occur simultaneously to varying extents. Encapsulation involves complete coating or enclosure of a contaminant particle with an additive or binder.

In situ immobilization methods typically involve amending sediments in place with agents such as cement, quicklime, grout, or pozzolanic materials, as well as other reagents. These agents are mixed through the zone of contamination using conventional excavation equipment or specially designed injection apparatus such as mixing blades attached to vertical augers. The effectiveness of immobilization technologies is variable depending on the characteristics of the contaminated matrix and the particular additives used. There are several potential limitations to this technology: solidified sediment may present problems as habitat for biota, reagent mixtures may be difficult to adjust and place accurately in a subaqueous setting and release of solidification agents and contaminated sediment to the water column during mixing may be difficult to control.</td><td>Full-scale applications of in situ immobilization of sediments are limited and have primarily focused on the improvement of the geotechnical properties of sediment for construction projects, as opposed to the goal of contaminant fixation. The two most applicable case studies that were found during a literature search are the Minamata Bay project in Japan, and a pilot study sponsored by the NJDOT in the New York-New Jersey Harbor Estuary. These case studies have been summarized and included in Appendix E: "Engineering Memoranda."</td><td>In general, in situ immobilization is more effective for inorganic constituents (i.e., metals) than for organic constituents (Federal Remediation Technologies Roundtable website: http://www.frtr.gov/matrix2/top_page.html). Neither of the case studies summarized in Appendix E: "Engineering Memoranda" provides sufficient data to evaluate the effectiveness of immobilization for the purpose of contaminant fixation.</td><td>Moderate to high. Limited cost data exists to support refined estimation of cost.</td><td>No</td></tr>
<tr><td>Erosion Control</td><td>Immobilization of surficial sediments could potentially be implemented to control erosion, but there is no known full scale application of in situ immobilization for this purpose.</td><td>There is a lack of available precedent for this process option, and therefore a lack of design parameters to evaluate potential effectiveness.</td><td>Moderate to high. Limited cost data exists to support refined estimation of cost.</td><td>No</td></tr>
<tr><td>Geotechnical Improvements</td><td>The use of in situ immobilization for improvement of sediment structural properties is fairly common and implementable.</td><td>Immobilization of deeper sediments may provide benefits such as shoreline protection. In addition, immobilization of sediments in an area to be dredged may reduce the sediment's potential for resuspension during dredging, and may also result in a stronger sediment bed which may not require sheetpile to maintain sidewall stability during dredging operations. Immobilization of sediments after dredging would also result in a more consolidated bed, which will likely be less prone to transport.</td><td>Moderate to high. Energy costs required for immobilization of LPR sediments could be significant.</td><td>Yes</td></tr>
<tr><td>Physical Extractive</td><td>Solvent Extraction / Surfactant Enhanced Recovery</td><td>Surfactant-enhanced extraction and solvent extraction were considered as in situ treatments. For in situ extraction, necessary system components include an injection system for delivery of the solvent or surfactant, a recovery system for the contaminant-bearing solvent or surfactant solution, and containment structures to prevent uncontrolled migration of the solvent or surfactant. Treatment or destruction of the surfactant or solvent would be accomplished ex situ.</td><td>Neither of these process options is considered to be applicable to the sediments of the area of focus for several reasons. Specifically, the non-homogenous consolidation of sediments may result in uneven solvent application and potential short-circuiting, and monitoring of extraction effectiveness would be difficult. In addition, failure of a containment system would have potentially deleterious effects on surrounding sediments and water quality.</td><td>There are no known sediment applications of these process options to demonstrate effectiveness.</td><td>Cost for sediment remediation projects unknown.</td><td>No</td></tr>
</table>

Table 3-1e: General Response Action: In Situ Treatment

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Biological Treatment	Biostimulation	Bioremediation is a technique in which the physical, chemical, and biological conditions of a contaminated medium are manipulated to accelerate the natural biodegradation and mineralization processes. Biodegradation is the process whereby microorganisms alter the structure of a chemical, while mineralization is the complete biodegradation of a chemical to carbon dioxide, water, and simple inorganic compounds. In nature, both partial biodegradation and complete mineralization take place; the processes, however, are frequently slow. Biostimulation and bioaugmentation are two processes used to enhance the rates of biodegradation and mineralization. Biostimulation involves the addition of amendments such as electron donors, eletron acceptors, and nutrients to stimulate biodegradation. Bioaugmentation involves the addition of engineered microbes that are known to degrade the contaminants of interest.	Persistent contaminants, such as those found in the sediments from the Area of Focus (e.g., PCB and PCDD/F), are frequently resistant to microbial degradation for the following reasons (Renholds, 1998): • Contaminant toxicity to the microorganisms. • Preferential feeding of microorganisms on other substrates. • Microorganisms' inability to use a compound as a source of carbon and energy. • Unfavorable environmental conditions in sediments for propagation of appropriate microorganisms. • Poor contaminant bioavailability to microorganisms. Since many of the contaminants are either not biodegradable (particularly heavy metals) or are very persistent in the environment (e.g., PCDD/F, PCB, pesticides), it is not considered feasible to implement these process options.	Given the large suite of contaminants present in sediment from the Area of Focus, even if some were amenable to bioremediation individually, it is unlikely that an optimal combination of microorganisms, nutrients, and carbon sources capable of treating the entire range of contaminants could be applied.	Unknown	No
	Bioaugmentation				Unknown	No
Chemical	Chemical Oxidation	In situ chemical treatment would involve the injection of chemical reagents, typically chemical oxidants or reductants, to chemically react with contaminants to form less toxic by-products.	Implementation of this technology is somewhat similar to implementation of the physical extractive technologies discussed above, and the limitations are similar. In addition, chemical treatment options are generally not well-suited to metals or to contaminants that are strongly sorbed to sediments.	Effectiveness in sediment remediation projects unknown.	Unknown	No

General Response Action Description: Removal						
Sediment removal is employed in those cases where contaminated sediments are to be withdrawn for ex situ treatment (refer to Table 3-1g "General Response Action: Ex Situ Treatment") and/or disposal or beneficial reuse (refer to Table 3-1h "General Response Action: Beneficial Use" and Table 3-1i "General Response Action: Disposal"). Contaminated sediment may be removed from a water body either while it is submerged (dredging) or after water has been diverted or drained (excavation). The process options evaluated include excavation, hydraulic dredging, mechanical dredging, and specialty dredging. The discussion of removal process options integrates site knowledge, previous sediment removal experience, and the results of the Dredging and Decontamination Pilot Study performed at the Lower Passaic River in December 2005 (Baron et al., 2005; Thompson et al., 2006; Bilimoria et al., 2006).						
Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Excavation	Excavator	Excavation of contaminated sediment involves pumping or diverting water from the area to be excavated, managing continuing inflow, and excavating contaminated sediment using conventional land-based excavators (such as backhoes). Dewatering an area for excavation can be achieved using: • Sheetpiling. • Earthen dams. • Cofferdams. • Inflatable dams. • Rerouting of the water body using temporary channels, dams or pipes.	Excavation technologies are conventional systems and are readily available in configurations and sizes that conform to the access limitations and other constraints of the area of focus. The ability to achieve hydraulic isolation of the contaminated area during remediation is a major factor in the selection of sediment excavation. For this reason, excavation technologies are not likely to be suitable for removing sediment from the main river channel due to the potential for high flow events, flooding, and navigation needs. Rather, excavation could be used to remove sediments from shallow areas such as along the shoreline.	Excavation technologies are effective and most applicable to removal of sediments that have been deposited along the river's shallow shoreline areas. Special closing buckets are available to reduce sediment losses and entrained water during excavation. Excavation is most effective when an area is hydraulically isolated using earthen dams, sheetpiling, or rerouting the water body using dams. Potentially effective in reducing volume of contaminants while concurrently minimizing mobility due to excavation operations.	The costs associated with excavation of contaminated sediment in the area of focus would be expected to be in the moderate to high range compared to the other process options under consideration due to additional costs of dewatering the areas to be excavated.	**Yes**
Dredging	Mechanical Dredging	The mechanical dredges most commonly used in the United States for environmental dredging are the clamshell, enclosed bucket, and articulated mechanical dredges (USEPA, 2005). The clamshell dredge is wire supported (i.e., "bucket-on-rope" system) from a barge-mounted derrick. Enclosed bucket dredges are also wire-supported but have been fitted with various types of covers, enclosures and seals to minimize the release of sediments during environmental removal operations. Articulated mechanical dredges are available in backhoe designs, clam-type enclosed buckets, and hydraulic closing mechanisms that are supported by an articulated fixed arm. An advantage of articulated mechanical dredges is that they allow for greater removal precision and have greater leverage to close on or cut debris. On the other hand, "bucket-on-rope" systems may be preferable when dredging softer contaminated sediments overlying a harder or impermeable non-contaminated layer. Enclosed "environmental" buckets, which are often fitted with seals and sensors, are frequently required for use on environmental dredging projects to reduce sediment resuspension. Mechanical dredges have the advantage of removing sediment with significantly less water entrainment as compared to hydraulic dredges. Anecdotal evidence suggests that typical entrainment of water for mechanical dredging of silty material could be on the order of 25 percent by volume. Low water content is beneficial if dewatering is required for sediment treatment or disposal.	The Dredging and Decontamination Pilot Study (Baron et al., 2005) performed in the Lower Passaic River in December 2005 demonstrated that mechanical environmental dredging techniques can successfully be implemented to remove sediments while limiting resuspension of sediments (Bilimoria, et al., 2006). An 8-cubic yard Cable Arm® mechanical clam shell bucket was used to dredge approximately 5,000 cubic yards of contaminated sediment from a 1.5-acre area in 10 to 15 feet of water. Sediment transport modeling predicted that dredging 5,000 cubic yards of sediment would result in an estimated 46 tons of silt and clay leaving the study area, assuming no flocculation. Resuspension monitoring results are currently being evaluated to determine the accuracy of the model predictions. Data analysis completed to date shows that the resuspended sediment plume is not distinguishable above background at the far field boundary.	During the Dredging and Decontamination Pilot Study (Baron et al., 2005), the effectiveness of the dredging equipment was evaluated with respect to the following parameters: productivity, precision (achieving targeted dredging depth and cut lines), turbidity levels, and operational controls. The average working day was 10 hours and the average dredging time was 6.4 hours, yielding an average up-time of 64 percent. The dredging rate averaged approximately 830 cubic yards per day. In terms of precision, the contractor's goal was to achieve a vertical accuracy of dredging of plus or minus six inches. An evaluation of the accuracy achieved was made by comparing the pre-dredging and daily post-dredging bathymetric survey data. Soundings on a 3 foot by 3 foot horizontal grid were plotted to determine their location with respect to the dredge prism. Soundings that fell within a given design cut elevation were compared to that elevation. Approximately 66 to 72 percent of the area (based on a comparison of individual survey points taken before and after dredging) was dredged within 6 inches of the design elevation, 82 to 89 percent of the area was dredged within 9 inches of the design elevation, and 92 to 94 percent of the area was dredged within 12 inches of the design elevation (Thompson, et al., 2006).	The costs associated with mechanically dredging contaminated sediments from the Area of Focus are expected to be in the low to moderate range.	**Yes**

Table 3-1f: General Response Action: Sediment Removal

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Dredging (continued)	Hydraulic Dredging	Hydraulic dredges remove and transport dredged materials as a pumped sediment-water slurry. Common hydraulic dredges include the conventional round cutterhead, horizontal auger cutterhead, open suction, dust pan, and hopper dredges. An important consideration in hydraulic dredging is the volume of water requiring treatment after dewatering from the dredge slurry. The greater the solids content of the dredge slurry, the lower the volume of water requiring treatment. Factors influencing the solids content include dredge type, nature of the sediment, the condition of the equipment, and operator skill and experience. It is important to note that utilization of hydraulic dredges would likely require significant infrastructure be constructed to convey, process, and dewater dredged slurry, and that this infrastructure would likely require a location of significant area near the site of dredging.	Hydraulic cutterhead dredges and suction dredges may be applicable to removing sediments from the area of focus since the sediments are primarily soft, free-flowing and unconsolidated. Both of these types of hydraulic dredges are readily available in the United States. To carry out hydraulic dredging operations, a long slurry line, possibly with booster pumps, would be needed to convey the sediment slurry to a processing facility or barge. This may impede river navigation, and as the length of the slurry line increases, the reliability of the dredging system may be reduced. In addition, hydraulic dredging operations often require significant area for land-based processing of dredged slurry. The productivity of hydraulic dredges, especially suction dredges, may be impacted by the presence of debris.	The degree of sediment resuspension may be expected to be somewhat less than would occur using mechanical dredges. It is important to note that utilization of hydraulic dredges would likely require significant infrastructure be constructed to convey, process, and dewater dredged slurry, and that this infrastructure would likely require a location of significant area near the site of dredging.	The costs associated with hydraulic dredging of contaminated sediments from the area of focus are expected to be in the low to moderate range. However, there could be significant real estate and operations and maintenance costs involved in dewatering the dredged material.	**Yes**
	Specialty Dredging	Numerous specialty dredges have been designed to address project-specific needs such as precise removal of sediments, removal of sediments from locations with access difficulties, and the need to minimize sediment resuspension. Several of these dredges have been developed and utilized in Canada, Europe, and Asia.	The use of specialty dredges is technically implementable. These dredges have been designed to address project-specific needs such accessibility and resuspension of sediments to be removed.	Specialty dredges are effective and may be used in areas of restricted access present in the Area of Focus. However, conventional dredges are generally more effective with regard to productivity and working conditions, and advances in environmental dredging have effected improvements in precision sufficient for most situations. Therefore, although specialty dredges will not be evaluated further in this FFS, they may be considered for managing specific situations that may become evident during a design phase.	Moderate to high.	**Yes (to be evaluated for specific uses that may be identified during design)**

General Response Action Description: *Ex Situ* Treatment						
Ex situ treatment technologies for sediments are generally classified as biological, chemical, extraction or washing, immobilization (solidification/ stabilization), and thermal (destruction or desorption) (USEPA, 2005). Ex situ treatment may be performed at a facility located near the river using mobile treatment units or more permanent treatment units contained within buildings, or it may be performed at a treatment facility located at a significant distance from the river. Although the same remedial technologies are potentially applicable for both near-river and off-site treatment of contaminated sediments, near-river treatment would reduce transportation and handling costs. For the purpose of this FFS, near-river is defined as a corridor that includes the river and extends 2 miles landward from each bank, and anywhere within the Port of New York and New Jersey. The applicability of complete or partial near-river treatment depends primarily on the availability of land for such a facility. This is discussed further in Section 4.0 "Development of Remedial Action Alternatives."						
Technology Class	**Process Options**	**Process Option Description**	**Implementability**	**Effectiveness**	**Cost**	**Retained**
Immobilization	Immobilization	Immobilization refers to treatment processes that physically or chemically reduce the mobility of hazardous constituents in a contaminated material. Immobilization treatment of dredged sediments improves material handling characteristics and may limit contaminant solubility and toxicity. Immobilization processes may include solidification, stabilization, and encapsulation, or a combination of these processes. Ex situ immobilization methods involve mixing setting agents such as cement, quicklime, grout, pozzolanic materials, and/or reagents with the material in a treatment unit. A treatment unit typically consists of a materials feed system, a reaction vessel equipped with mixing equipment, and an area for curing. Dredged material generally requires some pre-processing, such as screening of oversized material, prior to Immobilization. The effectiveness of immobilization technologies is variable depending on the characteristics of the dredged sediment and the particular additives used. Immobilization of dredged sediment is commonly required prior to its use in a beneficial application, such as for construction fill. A knowledge base for this technology exists within the Port of New York and New Jersey region using navigationally dredged material; project examples include the Orion of Elizabeth New Jersey (OENJ) shopping mall construction, OENJ Bayonne golf course, and EnCap Golf Holdings, LLC golf course in Lyndhurst, New Jersey.	Immobilization is technically implementable. Fixation agents and equipment required to mix them with the dredge material are readily available. This technology has been used widely to treat soil contaminated with the compounds of concern in the sediments of the Area of Focus. Treatability studies must be performed prior to full-scale implementation for sediments from Area of Focus to determine the appropriate type and amount of binding agents. Since contaminants are not removed or destroyed using this technology, the immobilized material will still require disposal at a landfill or at a beneficial reuse facility.	The effectiveness of immobilization is variable depending on the characteristics of the dredged material and the particular additives used. The volume and weight of the dredged material may increase significantly depending on the amount of binding agent used. If the material is to be taken to a landfill or used for a beneficial application (e.g., construction fill), the effectiveness of the process will be defined by standards setting maximum contaminant concentrations in leachate from the treated material, or contaminant concentrations in the bulk matrix of the treated material. Addition of stabilization material can also result in dessication of free liquid and an improvement of geotechnical properties.	The relative costs of ex situ immobilization are typically low to moderate compared to other treatment technologies. Costs depend on dredged material characteristics, the types of additives used, and the level of contamination in the dredged material.	**Yes**
Physical/ Chemical Extractive	Solvent Extraction / Surfactant Enhanced Recovery	Solvent extraction involves the use of an organic solvent as an agent to separate primarily organic contaminants from the dredged sediment. To accomplish this, the organic solvent is mixed with dredged sediment in an extraction unit. The extracted solution then is passed through a separator, where the contaminants and extractant are separated from the material. Generally the liquid extractant waste stream requires further treatment, such as other chemical or physical separation processes to separate the contaminants and recover the solvent. In some instances, solvent extraction is combined with particle separation (i.e., sediment washing) and with a metals stabilization process.	This process is implementable and could be combined with sediment washing.	In the case of the sediments from the Area of Focus, solvent extraction as a single treatment process would likely be insufficient to treat the dredged sediment, given the variety of contaminants, including heavy metals.	The relative costs of this technology are expected to be low to moderate. Costs vary depending on the type of washing reagents, the level of contamination in the dredged sediment (which affects the number of passes through the system required to meet treatment goals), the fraction of fine-grained materials in the sediment, and the options available to dispose of waste liquids and solids.	No

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Physical/ Chemical Extractive (continued)	Sediment Washing	Sediment washing is a water-based volume reduction process similar to the soil washing techniques used in the mining industry. During this process contaminants are extracted and concentrated into a small residual portion of the original volume using physical and chemical means (USEPA, 2005). Sediment washing is based on the same principle as solids classification. Since organic and inorganic contaminants tend to preferentially bind, either chemically or physically, to smaller-sized particles such as clay and silt, sediment washing separates the fine fraction of sediment from the coarser particles, thereby concentrating the contaminants and reducing the volume of material requiring additional treatment or disposal. Consequently, sediment washing has greater effectiveness for treating sediments with large fractions of coarser-grained particles. Under the Sediment Decontamination Technology Demonstration Program (see NJDOT website: www.state.nj.us/transportation/works/maritime/dresediment.shtm), several sediment decontamination technologies have been tested, including sediment washing. Typically sediment washing solutions consist of water or water in combination with organic solvents, chelating agents, surfactants, acids, bases, or oxidants.	Sediment washing is technically and administratively feasible as demonstrated by BioGenesis™ Enterprises, Inc. in a small-scale demonstration project performed in 1999-2000. Approximately 700 cubic yards of dredged material from a site in Newark Bay were treated. Also, BioGenesis[SM] Enterprises, Inc. recently treated approximately 2,620 cubic yards of dredged material from the Lower Passaic River in 2005/2006 as part of the Dredging and Decontamination Pilot Study. The recent BioGenesis™ Enterprises, Inc. study was designed to confirm the ability of the BioGenesis[SM] process to treat contaminated sediments to levels acceptable for beneficial use and to develop commercial scale operational and cost data. A draft technical memorandum presenting the results of the 2005/2006 pilot study is included in Appendix H "Dredged Material Management Assessments".	The effectiveness of this technology varies depending on the grain-size distribution of the dredged material. Sediment washing is typically most effective in treating sediments with smaller fractions of fine-grained particles, such as clay and silt. The sediments of the Area of Focus that would potentially be removed are composed primarily of silty sands and sandy silts. The BioGenesis[SM] Enterprises, Inc. process applies collision impact forces (to strip the biofilm layer and adsorbed contaminants from sediment particles) as well as cavitation/oxidation to enhance sediment washing. The decontaminated sediment is used to produce a manufactured soil or topsoil as a beneficial use product. The decontaminated sediment from the 2005/2006 demonstration met the New Jersey Residential Soil standards for metals, pesticides, and total PCB congeners, but not for certain PAHs. The overall processing (including soil manufacturing) was able to reduce the average concentrations for the PAHs to levels below the residential soil criteria. A draft technical memorandum presenting the results of the 2005/2006 pilot study is included in Appendix H "Dredged Material Management Assessments".	The relative costs of this technology are expected to be low to moderate. Costs vary depending on the type of washing reagents, the level of contamination in the dredged material (which affects the number of passes through the system required to meet treatment goals), the fraction of fine-grained sediments, and the options available to dispose of waste liquids and solids.	**Yes**
Biological Treatment	Biostimulation	Bioremediation is a technique in which the physical, chemical, and biological conditions of a contaminated medium are manipulated to accelerate the natural biodegradation and mineralization processes (see Table 3-1e "General Response Action: *In situ* Treatment").	The same limitations that apply to *in situ* bioremediation also apply to ex situ bioremediation of dredge material from the area of focus. Namely, there are many types of contaminants in the area of focus sediment, many of which are not amenable to biological treatment (particularly heavy metals) or degrade at very slow rates (e.g., PCDD/F, PCB, and pesticides). It is not considered feasible to design a biological treatment protocol that could treat this wide range of contaminants.	Given the large suite of contaminants present in the area of focus sediment, even if some were amenable to bioremediation individually, it is unlikely that an optimal combination of microorganisms, nutrients, and carbon sources capable of treating the entire range of contaminants could be applied.	Low.	No
	Bioaugmentation				Low.	No

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Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Thermal Treatment	Thermal Desorption	Thermal desorption involves the application of heat to below-combustion temperatures, typically 200 degrees Fahrenheit (°F) to 1,000°F, to volatilize water and organic contaminants. Dewatering prior to treatment is usually appropriate to avoid excess costs associated with thermally driving off moisture. Thermal desorption processes take place under anoxic conditions to prevent combustion. A carrier gas or vacuum system transports volatilized water and organics to a condenser or a gas treatment system (e.g., a high-temperature, secondary combustion chamber). Thermal desorption processes may be grouped into two categories based on the operating temperature of the desorber: high temperature thermal desorption (HTTD) or low temperature thermal desorption (LTTD). HTTD processes typically operate at 600°F to 1,000°F, while LTTD processes operate at 200°F to 600°F and have been most successful for remediating petroleum hydrocarbon contamination in soil. HTTD processes would be most applicable to Lower Passaic River sediments, as a temperature below 800°F is generally not sufficient to release PCBs from soil or sediment.	There are many commercially available HTTD processes. HTTD systems may be fixed structures or they may be portable. Capacities of portable systems are generally on the order of 20 to 100 tons per hour, which may be inadequate for large dredging projects. In addition, dredged material may need to be dewatered to obtain low moisture content (around 20 percent) since throughput is greatly impacted by this parameter.	The efficiency of thermal desorption decreases with increased soil moisture content. Clay and silty soils and high humic content soils increase reaction time as a result of binding of contaminants (FRTR website). Another potential limitation to the effectiveness of these units with respect to dredged material from the Area of Focus is that they are not typically designed to treat materials containing heavy metals. The presence of heavy metals will likely produce a treated solid residue that requires further processing before disposal or reuse.	The costs of thermal desorption are low to moderate. However, there could be significant real estate and operations and maintenance costs involved in dewatering the dredged sediments.	No

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Thermal Treatment (continued)	Thermal Destruction	Thermal destruction is a controlled process that uses high temperatures to destroy hazardous contaminants. The specific products of thermal destruction vary depending on the types of wastes that are burned and the operating parameters. Most thermal destruction units consist of a waste feed system, an air or oxygen-fed burner system, a combustion chamber, a combustion monitoring system, and equipment for air pollution treatment and control and ash removal. Thermal destruction temperatures are typically between 1,400°F and 2,200°F, which is sufficient to volatilize and combust organic chemicals. These processes tend to be expensive due to high energy costs, and they do not destroy heavy metals. Thermal destruction systems may be fixed, mobile, or transportable. Fixed systems are typically off-site TSCA and RCRA-permitted incineration facilities. The use of these facilities requires that sediments be dewatered prior to transportation to the facilities. On-site fixed systems could be constructed, but additional lead time would be required for permitting, construction, and testing. Mobile thermal destruction systems may be brought to a site and then removed at the conclusion of remediation. They normally include the equipment and supporting systems necessary for operation of the facility, such as electric-power generation equipment, a fuel supply, and equipment to collect and dispose of wastewater. Transportable equipment differs from mobile equipment in that it requires a significant installation effort. This equipment is provided in modular components and must be assembled before use. Transportable systems are designed so that they may be dismantled, removed, and re-installed at another site. Transportable systems may have capacities on the order of 100 tons per hour while mobile systems may have capacities around 30 tons per hour. One of the sediment decontamination technologies tested under the Sediment Decontamination Technology Demonstration Program (see NJDOT website: www.state.nj.us/transportation/works/ maritime/dresediment.shtm) is the Cement-Lock® process. This process is a thermo-chemical treatment process developed by the Gas Technology Institute (GTI) that decontaminates sediment and also converts it into construction-grade cement.	The primary implementability issues associated with thermal destruction are unit throughput, transportation to thermal treatment facilities, and availability of sufficient treatment capacity for sediments from the area of focus. Mobile and transportable systems have throughputs that may be inadequate for large dredging alternatives. There are several thermal treatment facilities that are permitted to accept dioxin-containing materials. These are primarily located in Canada, Texas, and the mid-west. Therefore, long-range transportation could be required to one or more of these facilities. Dewatering would be required prior to transportation of dredge material to a thermal treatment facility. The cost difference between shipping dredged sediments to the western United States and constructing a local treatment facility may provide an economic incentive for the construction of a near river thermal destruction facility. A Cement-Lock®-type facility could also provide an economic incentive via the production of a beneficial use product, as well as coupling such a facility with an energy co-generation plant.	Thermal destruction is very effective in destroying organic contaminants in sediment. Organic contaminant destruction and removal efficiencies are typically on the order of 99.9999 percent. Heavy metals may accumulate in the ash that remains after thermal treatment and would need to be treated or disposed (note that in the Cement-Lock® process, heavy metals are bound to the cement matrix). Proper thermal treatment operation is required to avoid formation of incomplete combustion products and to ensure that air pollution control devices adequately treat off-gas from the thermal treatment process. A Cement-Lock® demonstration plant was constructed in Bayonne, New Jersey, and operated from December 2003 through the end of March 2005. A complete description of plant operations is provided in a report dated July 2005 (Mensinger and Sheng, 2005). More recently (December 2006), approximately 16.5 tons of sediment from the Passaic River were processed at the Bayonne location (see technical memorandum in Appendix H: "Dredged Material Management Assessments") . Operational difficulties were encountered due to slag build-up in the kiln and due to freezing temperatures. Flue gas in the stack was analyzed for SO_2, NOx, CO, VOCs, metals, PCBs, dioxins and furans during two operating days. The results showed high destruction and removal efficiencies for contaminants of concern, including dioxins, furans, and PCBs. The activated carbon bed adsorber captured an average of 86.7% of the mercury entering the adsorber. Another test campaign is currently being planned for late April/early May 2007 to demonstrate the ability of the Cement-Lock plant to reliably handle a larger throughput of Passaic River sediment.	Thermal destruction costs are high to very high compared to other technologies. The high energy requirements and necessary emissions controls are primary contributors to elevated costs. Significant transportation costs would likely be incurred to convey sediments from the Area of Focus to an off-site incineration facility. For a new on-site or near-site thermal destruction facility, unit costs would be dependent on the amortization period allowed for recouping capital construction costs. Production of a beneficial use product (e.g., EcoMelt cement produced by Cement-Lock® process) could off-set high treatment costs, resulting in overall costs in the moderate price range.	**Yes**

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Thermal Treatment (continued)	Vitrification	Vitrification is a process in which higher temperatures (2,500°F to 3,000°F) are used to destroy organic chemicals by melting the contaminated sediment to form a glass aggregate product. Trace metals are trapped within the leach-resistant, inert glass matrix. Various types of vitrification units exist that utilize different techniques to melt the sediments, including those fueled by electricity and by natural gas. One technique used in vitrification is plasma vitrification, a process that involves superheating air by passing it through electrodes of a plasma torch. Partially screened and dewatered sediment is injected into the plume of the torch and heated rapidly. After dredging, dredge material must be dewatered to approximately 50 percent solids. Additional drying is required to further reduce moisture. Rotary steam-tube dryers or other indirectly heated drying systems are used for this purpose. The high temperature combusts and destroys the organic contaminants and the mineral phase melts in a glass matrix. Fluxing agents such as calcium carbonate, aluminum oxide, and silica oxide are blended with the sediment, as needed, to obtain the desired molten glass viscosity. The molten glass is quickly quenched, resulting in a product suitable for a wide variety of applications. Another technique used in vitrification is glass furnace technology; this process uses an oxy-fuel-fired glass furnace to vitrify sediment into an inert glass aggregate product. Sediment is dewatered and partially dried before being fed into the glass furnace. The high temperature melts the sediments, resulting in a homogenous glassy liquid. Additives such as calcium carbonate, aluminum oxide, and silica oxide are added to obtain the desired viscosity of the molten glass. The molten glass is collected and cooled quickly in a water quench to form glass aggregate product. The final glass product has a wide range of industrial applications.	The implementability issues for vitrification are similar to those for thermal destruction. Namely, they are vitrification facility unit throughput, transportation to existing vitrification treatment facilities, and availability of sufficient treatment capacity for dredged sediments from the Area of Focus. Dewatering would be required prior to transportation of dredged sediments to a vitrification facility. The vitrification technology has been commercialized by Minergy Corporation, which operates facilities in Neenah and Winneconne, Wisconsin, and is constructing another facility in Zion, Illinois. Currently no full-scale operating facility exists with sufficient capacity to accept large volumes of dredged sediments from the Area of Focus; therefore, construction of a new facility would potentially be required.	Vitrification units may be operated to achieve 99.9999 percent destruction and removal efficiency for PCB and PCDD/F (Retec Group, Inc., 2002). Minergy has performed multiple tests on PCB-contaminated sediment from the Fox River. A 2001 demonstration achieved a PCB destruction of greater than 99.99993 percent. It is anticipated that similarly high destruction efficiencies would be achieved for organic contaminants present in the sediments from the Area of Focus. In the vitrification process, heavy metals are trapped within the glass matrix from which they cannot leach. The glass aggregate was subjected to several leaching procedures, and no PCB congeners or heavy metals were detected in the leachate. PCDD/Fs were not detected during the sediment treatment process. The resulting glass aggregate has a wide range of industrial applications including roofing shingle granules, industrial abrasives, ceramic floor tile, and construction fill.	Vitrification costs are expected to be moderate compared to other technologies. Costs are highly dependent on the size of the vitrification unit. For new units, the cost is dependent on the anticipated operation time-frame for the facility; the longer the operation time-frame, the lower the costs because initial capital costs may be amortized over a longer time period.	**Yes**

Table 3-1h: General Response Action: Beneficial Use of Dredged Sediment

General Response Action Description: Beneficial Use of Dredged Sediment						
Beneficial use may be an appropriate management option for treated or untreated dredged sediment resulting from a dredging project. Significant cost savings may be realized if physical and chemical properties of the dredged sediments allow for beneficial use. Beneficial use options may entail using the dredged sediment in its original form, or treating the sediment to destroy chemical contaminants, and processing the treated sediment to create a useable product. Beneficial use options discussed below involve using dredged sediment in its dewatered or treated form. Options that involve treating the sediment first to create a beneficial commercial product are discussed in Table 3-1g. The nature of the contamination of the sediments in the Area of Focus may limit the beneficial use options that may be considered.						
Technology Class	**Process Options**	**Process Option Description**	**Implementability**	**Effectiveness**	**Cost**	**Retained**
Beneficial Use	Sanitary Landfill Cover	The dredged material may be beneficially used as a sanitary landfill cover. Daily sanitary landfill covers are used to control blowing of waste materials, to reduce odors, and to control the entry of water into the landfill during operations. Final sanitary landfill covers serve to prevent migration of landfill gas and to limit entry of water to the landfill.	Sanitary landfills accept dredged material on a case-by-case basis. Individual landfills must be contacted to determine if dredged material is appropriate for daily cover, interim cover, or final cover. Dredged material must meet a facility's waste acceptance criteria as well as any physical characteristics required for a particular use. Dewatering or desiccation via amendment to meet the paint filter test would be a minimum requirement. Given the restrictions placed on land disposal of PCDD/F-containing materials (see Appendix H: "Dredged Material Management Assessments"), only a small portion of the sediment from the area of focus would likely be suitable for landfill cover.	Using the dredged sediment in its original form or after it is processed (i.e., solidified/stabilized) is a potentially effective method for final disposal. Any beneficial use must take into account potential human and ecological health risks associated with exposure to contaminants in the sediment.	The costs of beneficially reusing sediment as sanitary landfill cover are estimated to be low compared to other options. Costs are variable, and they depend on the degree of preprocessing or treatment required, requirements for transportation to the construction location, and the disposal tipping fee.	**Yes**
	Construction Fill and/or Brownfields Remediation Material	Dredged material may be beneficially used as construction fill or brownfields remediation material. Fill material has to be compacted and strong enough to bear loads. In addition, the material may need to meet certain standards for contaminant concentrations.	This beneficial use option may be suitable for sediments with low concentrations of contaminants, especially if these sediments are subjected to a relatively low-cost treatment such as immobilization. One example of such a project is the EnCap Golf Holdings, LLC redevelopment project in the Meadowlands area in New Jersey. EnCap Golf Holdings, LLC is accepting dredged material for this redevelopment project for a fee of approximately $5 to $15 per cubic yard (based on term sheet dated April 1, 2004) with the higher end of the range applying to sediment that does not meet the processed dredged material specifications for hydraulic conductivity, compressive strength, and particle size. EnCap Golf Holdings, LLC requires that material that is delivered to the site pass the requirements listed in the NJDEP manual The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Water (NJDEP, 1997). This manual specifies sampling and analytical requirements for upland disposal and beneficial use of dredged materials in the State of New Jersey. In addition, dredged materials are required to pass the Paint Filter test. As of this writing, little if any capacity remains at EnCap Golf Holdings, LLC; however, it is possible for a similar facility to be permitted in the future. In addition, brownfields redevelopment opportunities may be identified for sediment use.	Using the dredged material in its original form or after it is processed (i.e., immobilized) is a potentially effective method for beneficial use. Any beneficial use must take into account potential human and ecological health risks associated with exposure to contaminants in the sediment.	The costs of beneficially reusing dredged material as construction fill or brownfields remediation material are estimated to be low compared to other options. Costs are variable, and they depend on the degree of preprocessing or treatment required and requirements for transportation to the construction location.	**Yes**

Table 3-1h: General Response Action: Beneficial Use of Dredged Sediment

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Beneficial Use (continued)	Mined Lands Restoration	Dredged material may be used as fill to restore abondoned mines.	The State of Pennsylvania, a leading coal producer, has many abandoned mines that could potentially use dredged material for restoration. The use of dredged material as mine reclamation material was evaluated in a project performed by the New York-New Jersey Clean Ocean and Shore Trust (New York/New Jersey Clean Ocean and Shore Trust and PaDEP, 2006). The project site was the Bark Camp Mine Reclamation Experimental Facility in central Pennsylvania. The Pennsylvania Department of Environmental Protection (PaDEP) established a pass/fail standard for maximum levels of contaminants acceptable for the demonstration. The maximum allowable dioxin concentration was 530 ppt, which is lower than the average 2,3,7,8-TCDD concentration of 810 ppt found in surface and subsurface sediments of the area of focus [Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006)], and Total PCB was 4 parts per million (ppm). Sediments dredged from a marina in New Jersey were transported to a portside facility where they were dewatered, off-loaded, screened, pre-amended, and loaded into railcars for shipment to Bark Camp. The pre-amended sediment was off-loaded from the railcars at the Bark Camp rail siding and hauled in off-road trucks to the processing pad at the mine facility. There, the sediment was processed with additional admixtures to create the final manufactured fill product. The fill was then spread and compacted in lifts along designated segments of the mine highwall. Three years after emplacement of the dredged sediment, Synthetic Precipitation Leaching Procedure (SPLP) testing of the final product emplaced in the highwall shows non-detects for metals and organics. In addition, water quality samples collected from six deep wells below the site, as well as surface water samples, pass drinking water quality standards. The implementability of mined lands restoration using dredge material from the area of focus depends largely on administrative issues such as thresholds for maximum contaminant concentrations acceptable to PaDEP. The recent PaDEP "Safe Fill" regulation/guidance may have different thresholds. It is unclear whether PaDEP would consider using leaching criteria instead of bulk contaminant concentrations. If leaching criteria were adopted, a larger portion of sediment from the area of focus might be eligible for disposal because organic contaminants are tightly bound to the sediment matrix and will likely leach only in low concentrations.	Using the dredged material in its original form or after it is processed (i.e., solidified/stabilized) is a potentially effective method for final disposal. Any beneficial use must take into account potential human and ecological health risks associated with exposure to contaminants in the sediment.	The costs of beneficially reusing sediment for mined land restoration are estimated to be low to moderate compared to other options. Costs are variable, and they depend on the degree of preprocessing or treatment required, requirements for transportation to the construction location, and the disposal tipping fee.	Yes

General Response Action Description: Disposal of Dredged Sediment						
Options involving sediment removal from the Lower Passaic River will require some means of final disposal, following treatment via ex situ techniques described in Table 3-1g: "*Ex Situ* Treatment," or at a minimum, by dewatering. Disposal site locations considered include land disposal and aquatic disposal. Beneficial use may be an appropriate management option for treated or untreated dredge material resulting from a dredging project. Significant cost savings may be realized if physical and chemical properties of the dredge material allow for beneficial use. Beneficial use options may entail using the dredged material in its original form, or treating the sediment to destroy chemical contaminants, and processing the treated material to create a useable product. Beneficial use options discussed below involve using dredged sediment in its dewatered or treated form. Options that involve treating the sediment first to create a beneficial commercial product are discussed in the Table 3-1g. The nature of the contamination of the sediments of the area of focus limits the beneficial use options that may be considered.						
Technology Class	**Process Options**	**Process Option Description**	**Implementability**	**Effectiveness**	**Cost**	**Retained**
Land Disposal	Off-Site Landfill	Land disposal options must ensure compliance with the land disposal restrictions (LDR) under the Hazardous and Solid Waste Amendments (HSWA) to RCRA (40 CFR 268.48). The LDR program identifies Universal Treatment Standards (UTS), which are numeric cleanup values for each hazardous constituent in wastes destined for land disposal. Treatment must achieve a 90% reduction in total constitutent concentration or ten times the UTS, whichever is greater.	Landfill acceptance of dredged material is determined on a case-by-case basis because permit requirements are facility-specific. Physical, chemical, and biological characteristics are needed to determine suitability for disposal. Most landfills require bulk chemical and waste extraction tests, and require that material meet the paint filter test, which may typically be accomplished with a solids content of 30 to 50 percent depending on the material characteristics (except for cases where landfills have re-handling capabilities). Contaminated dredged material may require additives/stabilization if it fails the paint filter test. Another consideration is that most disposal facilities permitted to accept PCDD/F-contaminated wastes are located a significant distance away from the area of focus, and hauling costs would be significant for any large dredging disposal project. Preliminary discussions have been held with NJDEP to assess the feasibility of permitting a local special use facility (e.g., landfill) dedicated to disposal of Lower Passaic River sediments. It is uncertain at this time whether this option is administratively feasible.	Land disposal in a hazardous waste landfill is an effective method for final disposal of dredged sediments. Off-site landfills would need to be permitted to accept the types and concentrations of contaminants present in the Lower Passaic River sediments.	Costs for off-site landfill disposal are expected to be moderate to high for dredged sediment that has not been treated prior to disposal. Dewatering and transportation costs will add to the total expense of off-site landfill disposal. In addition, in accordance with RCRA, the generator of hazardous waste that is disposed at a landfill faces long-term liabilities in the event that the waste is mismanaged.	**Yes**
	Upland Confined Disposal Facility	Land disposal of dredge material may be accomplished in upland confined disposal facilities (CDFs). CDFs are engineered structures enclosed by dikes and specifically designed to contain sediment. CDFs may accommodate mechanically or hydraulically dredged sediments and can be designed and operated to accomplish both dewatering and encapsulation. They may be considered as final disposal sites or as temporary rehandling sites for storage or processing prior to sediment treatment. A CDF may be integrated with site reuse plans to both reduce environmental risk and simultaneously foster redevelopment in urban areas and at brownfields sites. Also, there may be innovative and environmentally protective ways to reuse dredged contaminated sediments in habitat restoration projects (e.g., placement of lightly contaminated material over highly contaminated materials to build up elevations necessary for eventual creation of clean emergent marshlands).	CDFs have been widely used for navigational dredging projects and some combined navigational/ environmental dredging projects, but are less common for environmental dredging sites, due in part to siting considerations (USEPA, 2005). The main challenge to implementability of this process option is typically locating a site that is proximal and large enough to accommodate construction of a CDF capable of accepting sufficiently large volumes of contaminated sediments. Several potential locations for siting a CDF have been identified and are discussed in a memorandum included in Appendix H: "Dredged Material Management Assessments". Upland CDFs are retained for further evaluation.	Effective method for final disposal of dredged sediments.	Moderate to high. Transportation costs will add to the total expense.	**Yes**

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Aquatic Disposal	Confined Aquatic Disposal	Confined Aquatic Disposal (CAD) of dredged material in open waters has been practiced for many years, primarily for navigational dredging projects. Restricted disposal involves controls beyond those applied in conventional projects in order to address risks or uncertainties associated with contaminated sediments. CAD involves subaqueous covering or capping of dredged sediments, whether they are simply placed on the bottom or deposited in depressions or excavated pits. CAD is currently used in Newark Bay for sediments generated as a result of navigational dredging. The Newark Bay CDF was constructed in 1997 to a specified size (26 acres) and depth (70 feet) by clamshell dredge (note that although it is referred to as a CDF, the Newark Bay facility is technically a CAD as defined in this document). The deeper, clean material was ocean-disposed at the Historic Area Remediation Site (HARS); the upper sediment was classified as Category II (i.e., unsuitable for unrestricted ocean disposal) and placed at the ocean Mud Dump Site and capped by Category I (suitable for ocean disposal) dredged material. Filling of the Newark Bay CDF or CAD was conducted in accordance with an approved operations and maintenance plan. Disposal operations were conducted via split-hull scows or offloading of clamshell dredges. Closure is planned to consist of filling the entrance channel and capping the deposited material with sand.	The construction of a subaqueous CAD unit in the navigable waters of the United States requires the following permits or permit equivalencies: a Department of the Army Permit pursuant to Section 10 of the Rivers and Harbors Act, Section 404 of the CWA, and Section 103 of the Marine Protection, Research, and Sanctuaries Act. Construction of a new CAD would necessitate the disposal of a large amount of dredged sediment to make room for a potentially large sediment removal project. Furthermore, it is likely that a new CAD cell in the Port of New York and New Jersey would require management of the contaminated surficial sediments. CAD applications in river systems are uncommon because of water depth requirements for navigation and recreation, as well as the potential scouring that can occur during high-flow periods. Therefore, construction of a new CAD facility would likely be restricted to Newark Bay. The presence of an existing CAD facility in Newark Bay demonstrates that this option is technically feasible. However, recent usage has been limited to emergency projects or projects with a demonstrated hardship (i.e., other cost-feasible options are not available). It should be noted that the existing CAD cell in Newark Bay has been used for navigational dredge material, which is likely less contaminated than material dredged from the area of focus. Disposal in CAD cells would essentially eliminate the potential for temporary storage because of the impacts associated with placement and redredging for treatment.	The effectiveness of a CAD unit is based on the long-term stability of the site, which is influenced by currents, water depth, and bathymetry. In addition, the precision of placement of the material into the CAD unit, and the ability to minimize sediment resuspension, are important considerations.	The costs of a CAD unit are expected to be low to moderate compared to other process options. Major cost items would be obtaining necessary permits, equivalencies, or approvals, excavating the CAD cell, transporting and disposing of the dredged sediment, and then transporting, disposing, and monitoring of dredged material from the Area of Focus.	No
	In-water Confined Disposal Facility	CDFs may be constructed as in-water sites (i.e., containment islands). CDFs are engineered structures enclosed by dikes and specifically designed to contain sediment. CDFs may accommodate mechanically or hydraulically dredged sediments and can be designed and operated to accomplish both dewatering and encapsulation. They may be considered as final disposal sites or as temporary rehandling sites for storage or processing prior to sediment treatment. There may be innovative and environmentally protective ways to reuse dredged contaminated sediments in habitat restoration projects (e.g., placement of lightly contaminated material over highly contaminated materials to build up elevations necessary for eventual creation of clean emergent marshlands).	CDFs have been widely used for navigational dredging projects and some combined navigational/ environmental dredging projects, but are less common for environmental dredging sites, due in part to siting considerations (USEPA, 2005). The main challenge to implementability is that in-water CDFs are difficult to site and present obstacles to obtaining regulatory approvals due to the required mitigation for impacts to benthic and aquatic habitat. In addition, there may be waterway impacts such as disruption of circulation patterns.	Effective method for final disposal of dredged sediments.	Moderate to high.	No

Technology Class	Process Options	Process Option Description	Implementability	Effectiveness	Cost	Retained
Aquatic Disposal (continued)	Nearshore Confined Disposal Facility	Confined Disposal Facilities (CDFs) may also be constructed as nearshore sites (i.e., one or more sides exposed to water). CDFs are engineered structures enclosed by dikes and specifically designed to contain sediment. CDFs may accommodate mechanically or hydraulically dredged sediments and can be designed and operated to accomplish both dewatering and encapsulation. They may be considered as final disposal sites or as temporary rehandling sites for storage or processing prior to sediment treatment. A CDF may be integrated with site reuse plans to both reduce environmental risk and simultaneously foster redevelopment in urban areas and at brownfields sites. Also, there may be innovative and environmentally protective ways to reuse dredged contaminated sediments in habitat restoration projects (e.g., placement of lightly contaminated material over highly contaminated materials to build up elevations necessary for eventual creation of clean emergent marshlands).	CDFs have been widely used for navigational dredging projects and some combined navigational/ environmental dredging projects, but are less common for environmental dredging sites, due in part to siting considerations (USEPA, 2005). At the Sitcum Waterway cleanup project in Tacoma, Washington, contaminated sediment was placed in a near shore fill in the Milwaukee Waterway, which was then developed into a container terminal. This is an example of a nearshore CDF integrated with site reuse. Based on a preliminary inspection of land use and waterway characteristics, several potential site for nearshore CDFs have been identified. These sites are amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any alternative.	Effective method for final disposal of dredged sediments.	Moderate to high. Transportation costs will add to the total expense.	**Yes**

Table 4-1: Preliminary Dredging Requirements for Navigationally Constrained Capping Alternatives

Dimension (Not to scale)		Assumed Dimension for FFS	Basis for Assumption	Applicable References
	Design Vessel Depth	Alternatives vary	Considering 3 alternatives: (1) Authorized depth, (2) Current Use, and (3) Future Use.	Appendix F
Authorized Channel Depth	Gross Underkeel Clearance	3' soft bottom	2' to 4' total typical, including: freshwater effects (0.5' for brackish ports); 2' safety clearance; plus trim, wave, and shallow water effects.	Engineering and Design – Hydraulic Design of Deep Draft Navigation Projects (USACE, 2006a)
	Advanced Maintenance Dredging	2'	2' to 3' typical. Depends on shoaling rate and cost effective maintenance interval.	Engineering and Design – Hydraulic Design of Deep Draft Navigation Projects (USACE, 2006a)
	Future Overdredge Allowance for Channel Maintenance	1'	1' to 3' typical. Expect payment for overdredging to be minimized because of potential for elevated disposal costs.	Engineering and Design – Hydraulic Design of Deep Draft Navigation Projects (USACE, 2006a)
	Cap Protection Buffer	2'	Dredging operations may exceed overdredging payment depths. Buffer zone required to prevent dredging of the cap during future channel maintenance.	Professional judgement; discussions with USACE; Guidance for In-Situ Subaqueous Capping of Contaminated Sediments (USEPA, 1998a)
Armor	Top of Cap	3' in non-armored areas; 5' in armored areas	Designs vary considerably. Erosional areas: 1.5' armor, 6" gravel filter, 2' sand (assume 5' constructed). Non-erosional areas: minimum 2.5' sand (assume 3' constructed). Geotextiles not used as substitute for filter layer(s).	Technical Report DOER-1: Guidance for Subaqueous Dredged Material Capping (Palermo MR, Clausner JE, Rollings MP, Williams GL, Myers TE, Fredette TJ, and Randall RE) (USEPA, 1998a); USACE Guidance for Subaqueous Capping (USACE, 1998); capping projects literature review
Sand	Bottom of Cap			
	Overdredge Allowance for Cap Construction	1'	0' to 2' typical for environmental remediation projects. 1' estimated from December 2005 environmental dredging pilot results.	Thompson *et al.*, 2006
		Dimensions Used for FFS (1)		
	Total in addition to authorized depth (non-armored areas)	**9'**		
	Total in addition to authorized depth (armored areas)	**11'**		
(1) When inventory may remain.				

Table 4-3: Summary of Estimates for Remedial Alternatives

Alternative	DMM Scenario	Dredged Material Volume	Volume of Material Required For Placement				Construction Durations				Alternative Cost			
		Dredged Sediment Volume [cy]	Backfill Material [cy]	Capping Material [cy]	Armor Material [cy]	Mudflat Reconstruction Material [cy]	Mobilization/ Demobilization [years]	CDF Construction [years]	Dredging and Capping/Backfilling [years]	Total Project [years]	Capital	Dredge Material Management	Operation and Maintenace	Total
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	A	10,960,000	2,100,000	-	-	208,000	0.5	2.5	9	12	$1,092,000,000	$763,000,000	$91,000,000	$1,947,000,000
	B										$1,092,000,000	$1,085,000,000	$95,000,000	$2,272,000,000
Alternative 2: Engineered Capping of Area of Focus	A	1,142,000	-	3,151,000	623,000	208,000	0.5	1.0	4	6	$537,000,000	$230,000,000	$96,000,000	$863,000,000
	B										$537,000,000	$477,000,000	$97,000,000	$1,111,000,000
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel	A	6,979,000	2,702,000	-	52,000	208,000	0.5	1.5	6	8	$901,000,000	$522,000,000	$94,000,000	$1,518,000,000
	B										$901,000,000	$847,000,000	$97,000,000	$1,845,000,000
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	A	4,432,000	-	3,080,000	429,000	208,000	0.5	1.5	4	6	$754,000,000	$418,000,000	$95,000,000	$1,267,000,000
	B										$754,000,000	$744,000,000	$97,000,000	$1,596,000,000
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use	A	6,148,000	-	2,453,000	95,000	208,000	0.5	1.5	5	7	$839,000,000	$489,000,000	$93,000,000	$1,421,000,000
	B										$839,000,000	$814,000,000	$96,000,000	$1,749,000,000
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel for Future Use and Removal of Fine Grained Sediment from Primary Erosional Zone and Primary Inventory Zone	A	7,010,000	-	2,368,000	49,000	208,000	0.5	1.5	6	8	$879,000,000	$524,000,000	$93,000,000	$1,496,000,000
	B										$879,000,000	$849,000,000	$96,000,000	$1,824,000,000

cy = cubic yards

Costs are rounded to the nearest million.

Table 5-1: Detailed Analysis of Alternatives
Criterion 1: Overall Protection of Human Health and the Environment

Alternative	Overall Protection of Human Health and the Environment
No Action	Not protective. Natural recovery processes would achieve some reduction in risk from current levels, but human health and ecological risks continue to be above acceptable levels. In addition, the contaminated sediment load from the Lower Passaic River to Newark Bay and the New York-New Jersey Harbor Estuary would continue.
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	Based on the risk evaluations summarized in Chapter 2 and presented in full in Appendix C "Risk Assessment," existing conditions present unacceptable risks to human health and the environment. Active remediation of the Area of Focus followed by MNR will achieve any threshold for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by the No Action alternative. The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus. The 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve RAOs through a fate, transport, and bioaccumulation model that is currently in development and not yet available for the FFS.
Alternative 2: Engineered Capping of Area of Focus	
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel	
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone	

Alternative	Compliance with ARARs [1]
No Action	None of the identified action-specific or location-specific ARARs are applicable to the No Action alternative.
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	Elements associated with implementation of active alternatives will include pre-construction activities, construction/operation of a support area, dredging, capping, CDF disposal, thermal treatment, and wastewater treatment and discharge. Activities will be designed and carried out in accordance with applicable ARARs (except those which may be waived by the Regional Administrator in accordance with CERCLA Section 121(d)) and accepted best management practices. A waiver of seasonal restrictions on dredging operations is assumed.
Alternative 2: Engineered Capping of Area of Focus	
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel	
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone	

[1] An analysis of the applicable Action-Specific and Location-Specific ARARs for elements associated with active alternatives is shown in Table 5-2.

Table 5-1: Detailed Analysis of Alternatives
Criterion 3: Long Term Effectiveness and Permanence

Alternative	Cancer Risks [1]		Non-cancer Risks (Hazard Index)				Ecological Risks (Hazard Index)		Adequacy and Reliability of Controls
	Ingestion of Fish	Ingestion of Crab	Ingestion of Fish		Ingestion of Crab		*Mink*	*Heron*	
			Adult	*Child*	*Adult*	*Child*			
No Action	4 x 10-3	3 x 10-3	6.8	31	5.2	27	52	5	No controls.
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	5 x 10-4	4 x 10-4	4.7	22	3.5	19	6	2	Removal of 11 million cy is permanent and effective. No on-going maintenance is required. Monitoring conducted.
Alternative 2: Engineered Capping of Area of Focus									Removal of 1.1 million cy conducted only in areas of mudflat reconstruction or armor placement. Capping is effective if well-designed, but requires on-going maintenance for permanence. Monitoring conducted.
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel									Removal of 7.0 million cy is permanent and effective. Capping is effective if well-designed, but requires on-going maintenance for permanence. Monitoring conducted.
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage									Removal of 4.4 million cy is permanent and effective. Capping is effective if well-designed, but requires on-going maintenance for permanence. Monitoring conducted.
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage									Removal of 6.1 million cy is permanent and effective. Capping is effective if well-designed, but requires on-going maintenance for permanence. Monitoring conducted.
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone									Removal of 7.0 million cy is permanent and effective. Capping is effective if well-designed, but requires on-going maintenance for permanence. Monitoring conducted.

(1) Residual cancer risks are for a combined adult/child receptor. Residual risks were calculated assuming a 30 year time period following implementation.

Table 5-1: Detailed Analysis of Alternatives
Criterion 4: Reduction of Toxicity, Mobility, and Volume Through Treatment

Alternative	Volume Removed (million cy)	Volume Treated(1) (million cy)	Degree of Expected Reduction in Toxicity, Mobility, or Volume
No Action	0	0	None.
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	11	1.7	Removal of contaminated sediments would permanently reduce the volume of contaminants in the Area of Focus. Volume removed by each alternative presented in "Volume Removed" column. Thermal treatment would irreversibly destroy (and thereby reduce the toxicity, mobility, and volume) of 99.9999 percent of contaminants in treated sediments. Alternatives 1, 3, 4, 5, and 6 treat the same volume of material (1.7 million cy), which is greater than the volume treated by Alternative 2 (1.2 million cy). Residuals associated with thermal treatment would be disposed in a secure landfill or CDF. Thermal treatment would meet the statutory preference for treatment. Dewatering and wastewater treatment processes would reduce toxicity, mobility, and volume of contaminants in process water, but would likely generate treatment residuals (*e.g.*, flocculation sludge and filter sands) whose quantities would depend on the sediment volume removed. Storage or disposal of dredged material in CDF would reduce the mobility of contaminated material but not the toxicity or the volume and would not meet the statutory perference for treatment. Greater volumes of material placed in the CDF would result in greater reductions in mobility. Capping methods would reduce mobility, but do not reduce contaminant toxicity or volume. Capping does not satisfy the the statutory preference for treatment.
Alternative 2: Engineered Capping of Area of Focus	1.1	1.1	
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel	7	1.7	
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	4.4	1.7	
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	6.1	1.7	
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone	7	1.7	

(1) Volume treated by dredged material management scenario B only. Volume is presented in millions of in situ cubic yards. The treatment volume of 1.7 million cy is based on CDF storage above the "mudline" prior to treatment, with the remainder of the removed sediments placed in an excavated area below the CDF.

Table 5-1: Detailed Analysis of Alternatives
Criterion 5: Short Term Effectiveness

<table>
<tr><th>Alternative</th><th>Protection of the Community</th><th>Protection of Workers</th><th>Environmental Impacts</th><th>Time until Remedial Response Objectives are Achieved</th></tr>
<tr><td>No Action</td><td>Existing risks to the community would be decreased minimally from current levels by natural recovery processes.</td><td>N/A</td><td>Existing impacts to the environment would be decreased minimally from current levels by natural recovery processes.</td><td>Natural recovery processes would continue to occur, but would require 40-50 years longer than active alternatives to achieve thresholds.</td></tr>
<tr><td>Alternative 1: Removal of Fine Grained Sediment from Area of Focus</td><td>Greatest amount of removal results in greatest disturbances to the community</td><td rowspan="6">Implementation of any active alternative (e.g. , dredging or capping) would potentially expose workers to contaminated sediment, with the extent of exposure dependent on project duration. A greater likelihood of exposure is associated with greater amounts of removal.

No quantification of risk due to exposure to contaminated sediment has been conducted, and the need for increased dermal and respiratory protection of workers has not been assessed.

Workers will be required to follow Occupational Safety and Health Administration (OSHA) regulations and project-specific health and safety plans.</td><td rowspan="6">Potential for resuspension of contaminated sediment and air/noise impacts are typically higher for dredging than capping.

Subtantial dredging prior to capping results in disturbance of benthic habitat, resuspension of contaminated sediment, and air/noise impacts.

Other possible impacts include a potential increase in the fish and shellfish tissue contaminant concentrations due to a temporary increase in suspended sediments.

Construction of a CDF would consitute a permanent impact, and would require that mitigation measures be undertaken.</td><td rowspan="6">The six active alternatives vary slightly in duration of implementation, as each alternative contains similar components including pre-design activities, design, mobilization, dredging, capping or backfilling, and demobilization.

Following implementation, trends in surface sediment concentrations for each active alternative are also comparable, as the post-implementation surface sediment concentrations achieved by each active alternative are equivalent. These trends may be influenced by the depositional conditions achieved by each alternative.</td></tr>
<tr><td>Alternative 2: Engineered Capping of Area of Focus</td><td>Least amount of removal results in least amount of disturbances to the community.</td></tr>
<tr><td>Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel</td><td>Amount of removal and resulting degree of disturbance less than Alternative 1 and similar to Alternative 6.</td></tr>
<tr><td>Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage</td><td>Amount of removal and resulting degree of disturbance less than Alternatives 1, 3, 5 & 6.</td></tr>
<tr><td>Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage</td><td>Amount of removal and resulting degree of disturbance less than Alternatives 1, 3 & 6.</td></tr>
<tr><td>Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone</td><td>Amount of removal and resulting degree of disturbance less than Alternative 1 and similar to Alternative 3.</td></tr>
</table>

Table 5-1: Detailed Analysis of Alternatives
Criterion 6: Implementability

<table>
<tr><th>Alternative</th><th>Technical Feasibility</th><th>Degree of Difficulty</th><th>Administrative Feasibility</th><th>Availability of Services and Materials</th></tr>
<tr><td>No Action</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Alternative 1: Removal of Fine Grained Sediment from Area of Focus</td><td>Modeled flooding impacts posed by 100-year flow event would be reduced from 499 acres to less than 482 acres.[1]</td><td rowspan="6">Technologies associated with each active alternative are well established and reliable.

Monitoring programs would be conducted for each active alternative.

The establishment of processing, staging, transportation, and treatment facilities could alleviate startup challenges associated with future remedial actions.

Access restrictions required to maintain integrity of cap.</td><td>No change in authorized depth of the navigation channel from RM0-RM8 required.</td><td rowspan="6">Dredging and capping are both well developed technologies; adequate, reliable, and available technology can be procured; no significant challenge to the implementability of any alternative.

A preliminary review of the environs of the Lower Passaic River and Newark Bay suggests there are various near-shore areas amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any active alternative.</td></tr>
<tr><td>Alternative 2: Engineered Capping of Area of Focus</td><td>Modeled flooding impacts posed by 100-year flow event would be increased from 499 acres to 592 acres.</td><td>Authorized depth of the navigation channel from RM0-RM8 would require change.</td></tr>
<tr><td>Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel</td><td>Modeled flooding impacts posed by 100-year flow event would be reduced from 499 acres to less than 482 acres.[1]</td><td>No change in authorized depth of the navigation channel from RM0-RM8 required.</td></tr>
<tr><td>Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage</td><td>Modeled flooding impacts posed by 100-year flow event would be increased from 499 acres to 523 acres.</td><td>No change in authorized depth of the navigation channel from RM0-RM1.2 required, but depth in RM1.2-RM8 would require change.</td></tr>
<tr><td>Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage</td><td>Modeled flooding impacts posed by 100-year flow event would be reduced from 499 acres to 482 acres.</td><td>No change in authorized depth of the navigation channel from RM0-RM1.2 required, but depth in RM1.2-RM8 would require change.</td></tr>
<tr><td>Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone</td><td>Modeled flooding impacts posed by 100-year flow event would be reduced from 499 acres to less than 482 acres.[1]</td><td>No change in authorized depth of the navigation channel from RM0-RM1.2 required, but depth in RM1.2-RM8 would require change.</td></tr>
</table>

(1) Alternatives 1, 3, and 6 not modeled. Reductions in flooding considered to be greater than modeled reductions for Alternative 5 due to similar bottom conditions and increased water depth.

Table 5-1: Detailed Analysis of Alternatives
Criterion 7: Cost

Alternative	Total Cost		Capital Cost (1)		Operations and Maintenance Cost			
					Annual Cost		NPV of Annual Cost [2]	
	DMM Scenario A	DMM Scenario B	DMM Scenario A	DMM Scenario B	DMM Scenario A	DMM Scenario B	DMM Scenario A	DMM Scenario B
No Action	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Alternative 1: Removal of Fine Grained Sediment from Area of Focus	$1950M	$2270M	$1860M	$2180M	$5.9M	$6.2M	$91M	$95M
Alternative 2: Engineered Capping of Area of Focus	$863M	$1110M	$770M	$1010M	$6.3M	$6.3M	$96M	$97M
Alternative 3: Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel	$1520M	$1850M	$1420M	$1750M	$6.1M	$6.3M	$94M	$97M
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	$1270M	$1600M	$1170M	$1500M	$6.1M	$6.3M	$95M	$97M
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	$1420M	$1750M	$1330M	$1650M	$6.2M	$6.4M	$93M	$96M
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine Grained Sediment from Primary Inventory Zone and Primary Erosional Zone	$1500M	$1820M	$1400M	$1730M	$6.2M	$6.3M	$93M	$96M

(1)Capital costs include dredged material management costs.
(2)Present worth costs have been generated based on estimates of capital costs, operations and maintenance costs, and contingency. Costs presented in 2006 dollars.

Table 5-2: ARARs for Pre-Construction

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Hazardous Material Transportation Act	49 U.S.C. §§ 5101 et seq.	• Covers transportation of any hazardous wastes. • EPA will make the determination on whether or not the dredged sediments qualify as hazardous waste.	Action Specific
Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 239 - 299	• Covers transportation and disposal of hazardous wastes. • EPA will make the determination on whether or not the dredged sediments qualify as hazardous waste.	Action Specific
Toxic Substances Control Act (TSCA)	15 U.S.C. §§ 2601 et seq.	• Governs transportation, handling and storage of PCB-contaminated waste with concentrations greater than 50 ppm. • Thus far, chemical analysis of river sediments has not exhibited samples above the TSCA limit. However, if the results of the pre-construction sampling effort show concentrations over the limit, TSCA may apply.	Action Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of existing wetlands will be required during the pre-design phase. Dredging activities may impact these wetlands requiring mitigation.	Location Specific

Table 5-2: ARARs for Construction and Operation of Support Area

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions from equipment.	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify any endangered or threatened species or their habitats in the areas impacted by construction or operation of a support area.	Location Specific
Hazardous Material Transportation Act	49 U.S.C. §§ 5101 et seq.	• Covers transportation of any hazardous wastes • Applies to the transportation of hazardous wastes generated during facility operations (e.g., waste oils, lubricants, etc.)	Action Specific
Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 239 - 299	• Covers disposal of operational wastes, oils, etc.	Action Specific
Rivers and Harbors Act	33 U.S.C. §§ 401 et seq.	• Applies to barge movement and anchoring.	Location Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify any historic properties or cultural resources which may be impacted by construction or operation of a support area.	Location Specific
New Jersey Coastal Zone Management Rules	N.J.A.C. 7:7E	• Covers construction of bulkhead, buildings, docks, launches, etc.	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of any existing wetlands will be required during the design phase. • Construction and operation activities may impact nearby wetlands areas.	Location Specific
New Jersey Soil Erosion and Sediment Control Act	N.J.S.A. 4:24-39 to 55	• Requires the development of a sediment control plan for any development or construction activities.	Location Specific
New Jersey Stormwater Management Rules	N.J.A.C. 7:8	• Covers activities which affect erosion, groundwater recharge, or runoff quantity and quality. • Applies to construction activities, paving, removal of vegetation, etc.	Action Specific

Table 5-2: ARARs for Dredging

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions from equipment and from dredged material.	Action Specific
Clean Water Act (CWA)	33 U.S.C. §§ 1251 et seq.	• For discharge of water (section 401) and discharge of dredged material (section 404).	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify endangered or threatened species or their habitats in the areas impacted by dredging operations.	Action Specific
Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 239 - 299	• Covers transportation and disposal of hazardous wastes. • EPA will need to make the determination on whether or not the dredged sediments qualify as hazardous waste.	Action Specific
Rivers and Harbors Act	33 U.S.C. §§ 401 et seq.	• Applies to barge movement and anchoring. • Covers sheet pile installation for protection of bulkheads, bridges, docks, and utilities.	Location Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify historic properties or cultural resources which may be impacted by dredging operations.	Location Specific
New Jersey Coastal Zone Management Rules	N.J.A.C. 7:7E	• Makes limitations on depth of cut, side slopes, and operational practices (BMPs). • Requires protection of bulkheads, bridges, piers, docks and utilities. • Authorizes NJDEP to impose seasonal restrictions on dredging activities. (We assume this requirement will be waived.)	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of existing wetlands will be required during the pre-design phase. • Dredging activities may impact these wetlands requiring mitigation.	Location Specific

Table 5-2: ARARs for Capping, Backfilling, Armoring and Mudflat Reconstruction

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions from equipment.	Action Specific
Clean Water Act (CWA)	33 U.S.C. §§ 1251 et seq.	• Covers discharge of fill material.	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify endangered or threatened species or their habitats in the areas impacted by capping activities.	Location Specific
Rivers and Harbors Act	33 U.S.C. §§ 401 et seq.	• Applies to barge movement and anchoring.	Location Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify any historic properties or cultural resources which may be impacted by capping activities.	Location Specific
New Jersey Coastal Zone Management Rules	N.J.A.C. 7:7E	• Covers filling in fish habitats or spawning areas.	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of existing wetlands will be required during the design phase. • Wetlands may be impacted by capping and backfilling, and by operation and movement of equipment. • Mudflats areas may be classified as wetlands.	Location Specific
New Jersey Stormwater Management Rules	N.J.A.C. 7:8	• Covers activities which affect erosion, groundwater recharge, or runoff quantity and quality. • Applies to stockpile runoff.	Action Specific

Table 5-2: ARARs for CDF Construction and Operation

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions for equipment.	Action Specific
Clean Water Act (CWA)	33 U.S.C. §§ 1251 et seq.	• Covers discharge of fill material.	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify endangered or threatened species or their habitats in the areas of the proposed CDF.	Location Specific
Hazardous Material Transportation Act	49 U.S.C. §§ 5101 et seq.	• Covers transportation of any hazardous wastes. • EPA will make the determination on whether or not the dredged sediments qualify as hazardous waste. • EPA will determine if the CDF is "on-site," and therefore not subject to transportation rules.	Action Specific
Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 239 - 299	• Covers transportation and disposal of hazardous wastes. • EPA will make the determination on whether or not the dredged sediments qualify as hazardous waste.	Action Specific
Rivers and Harbors Act	33 U.S.C. §§ 401 et seq.	• Applies to barge movement and anchoring. • Applies to construction and use of off-loading docks, etc.	Location Specific
Toxic Substances Control Act (TSCA)	15 U.S.C. §§ 2601 et seq.	• Governs transportation, handling and storage of PCB-contaminated waste with concentrations greater than 50 ppm. • Thus far, chemical analysis of river sediments has not exhibited samples above the TSCA limit. However, if the results of the sampling effort show concentrations over the limit, TSCA may apply.	Action Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify any historic properties or cultural resources which may be impacted CDF construction or operation.	Location Specific
New Jersey Air Quality Regulations	N.J.A.C. 7:27	• Applicable if volatile contaminants in the dredged material are likely to affect air quality.	Action Specific
New Jersey Coastal Zone Management Rules	N.J.A.C. 7:7E	• Covers working in fish habitats or spawning areas.	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of any existing wetlands in the area of the proposed CDF will be required during the design phase.	Location Specific
New Jersey Stormwater Management Rules	N.J.A.C. 7:8	• Covers activities which affect erosion, groundwater recharge, or runoff quantity and quality. • Applies to changes in runoff characteristics once the CDF is closed.	Action Specific

Table 5-2: ARARs for Onsite Thermal Treatment

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions from equipment. • Covers emissions from operations of treatment system.	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify any endangered or threatened species or their habitats in the areas of the proposed thermal treatment facility.	Location Specific
Hazardous Material Transportation Act	49 U.S.C. §§ 5101 et seq.	• Covers transportation of any hazardous wastes. • EPA will make the determination on whether or not the dredged sediments qualify as hazardous waste. • EPA will determine if the CDF is "on-site," and therefore not subject to transportation rules.	Action Specific
Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 239 - 299	• Covers treatment, storage, and disposal of potentially hazardous waste. • Specifies destruction and removal efficiencies (DRE) limits for the process.	Action Specific
Rivers and Harbors Act	33 U.S.C. §§ 401 et seq.	• Applies to construction and use of off-loading docks, etc., if not contiguous with CDF.	Location Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify any historic properties or cultural resources which may be impacted by the proposed thermal treatment facility.	Location Specific
New Jersey Air Quality Regulations	N.J.A.C. 7:27	• Applicable to emissions from the facility during operation. • Also covers emissions from construction equipment.	Action Specific
New Jersey Coastal Zone Management Rules	N.J.A.C. 7:7E	• Covers working and transporting across coastal zone from CDF to thermal treatment location.	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of any existing wetlands in the area of the proposed thermal treatment facility will be required during the design phase.	Location Specific
New Jersey Soil Erosion and Sediment Control Act	N.J.S.A. 4:24-39 to 55	• Requires the development of a sediment control plan for any development or construction activities.	Location Specific
New Jersey Stormwater Management Rules	N.J.A.C. 7:8	• Covers activities which affect erosion, groundwater recharge, or runoff quantity and quality. • Applies to changes in runoff characteristics caused by construction of the facility.	Action Specific

Table 5-2: ARARs for Wastewater Treatment and Discharge

ARAR	Citation(s)	Rationale	Action Specific/ Location Specific
Clean Air Act	42 U.S.C. §§ 7401 et seq.	• Covers emissions from equipment. • Covers emissions from operations of treatment system.	Action Specific
Endangered Species Act	16 U.S.C. §§ 1531-1544	• Survey will be required during design phase to identify endangered or threatened species or their habitats in the areas of a proposed wastewater treatment facility. • The survey will also indicate potential impacts on threatened or endangered species from discharge of effluent.	Location Specific
General Pretreatment Regulations for Existing and New Sources of Pollution	40 C.F.R. § 403	• Sets regulations on contaminant concentrations for waters to be treated at a publicly owned treatment works (POTW).	Action Specific
Federal and State Effluent Standards	N.J.A.C. 7:14A; 33 U.S.C. §§ 1251 et seq.	• Sets contaminant concentration limits for effluent from a wastewater treatment plant.	Action Specific
Federal and State Historic Preservation Acts	16 U.S.C. § 470; N.J.S.A. 13:1B	• Survey will be required during design phase to identify historic properties or cultural resources which may be impacted by a proposed wastewater treatment facility. • The survey will also show possible impacts of effluent discharge on historic or cultural resources.	Location Specific
New Jersey Air Quality Regulations	N.J.A.C. 7:27	• Applicable to emissions from the facility during operation. • Also covers emissions from construction equipment.	Action Specific
New Jersey Coastal Zone Management rules	N.J.A.C. 7:7E	• Covers working and building in the coastal zone.	Location Specific
New Jersey Freshwater Wetlands Protection Act Rules	N.J.A.C. 7:7A	• Delineation of existing wetlands in the area of any proposed wastewater treatment facility will be required during the design phase. • Impacts of a discharge of treated water on nearby wetlands areas will also be considered in the design phase.	Location Specific
New Jersey Soil Erosion and Sediment Control Act	N.J.S.A. 4:24-39 to 55	• Requires the development of a sediment control plan for any development or construction activities.	Location Specific
New Jersey Stormwater Management Rules	N.J.A.C. 7:8	• Covers activities which affect erosion, groundwater recharge, or runoff quantity and quality. • Applies to changes in runoff characteristics caused by construction of a facility.	Action Specific